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Seabasing and Joint Expeditionary Logistics

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13. ABSTRACT *(maximum 200 words)*

Recent conflicts such as Operation Desert Shield/Storm and Operation Iraqi Freedom highlight the logistics difficulties the United States faces by relying on foreign access and infrastructure and large supply stockpiles ashore to support expeditionary operations. The Navy's transformational vision for the future, Sea Power 21, involves Seabasing as a way to address these difficulties by projecting and sustaining joint forces globally from the sea. This study analyzes logistics flow to, within and from a Sea Base to an objective, and the architectures and systems needed to rapidly deploy and sustain a brigade-size force. Utilizing the Joint Capabilities Integration and Development System (JCIDS), this study incorporates a systems engineering framework to examine current systems, programs of record and proposed systems out to the year 2025. Several capability gaps that hamper a brigade-size force from seizing the initiative anywhere in the world within a 10-day period point to a need for dedicated lift assets, such as high-speed surface ships or lighter-than-air ships, to facilitate the rapid formation of the Sea Base. Additionally, the study identifies the need for large-payload/high-speed or load-once/direct-to-objective connector capabilities to minimize the number of at-sea transfers required to employ such a force from the Sea Base in 10 hrs. With these gaps addressed, the Joint Expeditionary Brigade is supportable from the Sea Base.

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Executive Summary

The 2004 Seabasing and Joint Expeditionary Logistics Integrated Project represents the combined effort of 50 students and 18 faculty members from different Naval Postgraduate School (NPS) departments. Utilizing tasking provided by the office of the Deputy Chief of Naval Operations for Warfare Requirements and Programs (OPNAV N7) to the NPS Wayne E. Meyer Institute of Systems Engineering, the project examines logistics flow to, within, and from a Sea Base to an objective in a joint warfare environment. The OPNAV N7 tasking requests the Meyer Institute to conduct a study to develop system of systems conceptual solutions for Seabasing and Joint Expeditionary Logistics (JELo) which use current systems, programs of record, and other proposed systems extending over the next 20 years. The Systems Engineering and Analysis Cohort Six (SEA-6) Team uses the Joint Capabilities Integration and Development System (JCIDS) as a systems engineering framework to conduct the multidisciplinary study.

Seabasing is an important part of Sea Power 21; however, analysis in this study indicates that 2004 capabilities, and the capabilities expected through the 2015 time frame, cannot support the aggressive operational timelines envisioned for future doctrine. In order to achieve these timelines by the 2025 time frame, several materiel and nonmateriel solutions are identified that offer promising investment possibilities to address the capability gaps.

Much of the current discussion involving the Sea Base and expeditionary operations revolves around a 10/30/30 construct and a brigade-size force. The 10/30/30 construct calls for expeditionary forces to seize the initiative within 10 days of a deployment order; achieve their expeditionary objectives within 30 days; and then reconstitute and redeploy within the next 30 days. Seizing the initiative is defined as the employment of ground forces to the initial objectives. In order to accomplish this, the expeditionary forces must rapidly transit to the Sea Base in the Area of Operations (AO) (Close) and marry up with prepositioned equipment (Assemble) through a Forward Logistics Site (FLS). Seizing the initiative also involves delivering

3 Battalion Landing Teams (BLT), 2 surface and 1 vertical, from the Sea Base to the objective ashore (Employ) in one 10-hr time period. The expeditionary forces are then supported for up to 30 days (Sustain) as they establish control of hostilities and achieve their objectives. The 2004 project employs the 10/30/30 operational construct to investigate the Closure, Assembly, Employment, and Sustainment Phases of seabased expeditionary operations.

Using JCIDS, the SEA-6 Team defines the problem, creates a scenario, develops modeling and simulation tools, and conducts analyses to draw conclusions and make recommendations. The team designs a 2015 Baseline Architecture (2015 BLA) for the Sea Base that is centered on the Maritime Prepositioning Force, Future (MPF(F)) ship. The project identifies, defines, and quantifies capability gaps, develops platform solutions, and generates three alternative architectures for Seabasing and JELo out to the 2025 time frame.

One of the alternative architectures for the 2025 time frame incorporates a high-speed assault connector ship[1] (Joint Amphibious Combat Cargo Expeditionary Support Ship (Joint ACCESS)) designed by students in the NPS Total Ship Systems Engineering (TSSE) Group to address a specific capability gap identified during the Employment phase of operations. A collaborative war game against a near-peer competitor is conducted with students in the NPS Operations Research Department in order to gain a different perspective on the performance of the 2015 BLA, based on man-in-the-loop simulation.

In order to identify and quantify the potential capability gaps for each architecture, SEA-6 develops a simulation model, the Systems Engineering and Analysis Baseline Architecture and Solution Evaluator-Six (SEABASE-6) model, using EXTEND™, a process-based, discrete-event modeling and simulation tool. A threat-based capability study results in the development of an operational scenario to

[1] Total Ship Systems Engineering Team, (2004), "Joint ACCESS: A High Speed Assault Connector for Amphibious Seabasing Operations and Joint Expeditionary Logistics," Naval Postgraduate School Technical Report, Monterey, CA, December 2004.

judge system performance under realistic and expected environmental and combative conditions. A designed experiment is used to plan an efficient data collection effort and operational requirements are used to formulate critical operational issues (COIs), measures of effectiveness (MOEs), and measures of performance (MOPs) to evaluate overall system performance.

Scenario effects are captured in the input variables of the SEABASE-6 simulation model to evaluate JELo system performance. Each of the JELo system architectures are influenced by sea state, level of combat (consumption rates), and range (both Sea Base to shore and shore to objective). Given the varying degrees of technological maturity, technological and operational risk, and affordability, the study focuses on the capability of various platforms and systems to meet requirements without trying to determine a specific combination for an overall best architecture design. Additionally, although cost is not a determining factor in the design of the various architectures, it is used as a tool to make relative comparisons.

The key findings of this study are:

- Programs of record for 2015 Sea Base forces are challenged to meet a 10/30/30 response timeline. Major capability gaps are highlighted in the various phases associated with these expeditionary operations (Closure, Assembly, Employment and Sustainment). Using three top-level performance measures as well as estimated cost, Table 1 provides a side-by-side comparison of each of the architectures evaluated in the study. It is apparent that each of the alternative architectures performs better than the 2015 BLA at a relatively lower cost; however, further analysis of the performance and cost of the three alternatives is required to determine which one holds more promise.

ARCHITECTURE	Closure Time (Days)	Employment Time (Hours)	Seize the Initiative (Days)	Total Cost (FY04$B)
Baseline	16	30	17	$34-$42
Alternative 1	13	10	13	$28-$35
Alternative 2	9	12	10	$29-$36
Alternative 3	9	9	10	$28-$35

Table 1: Architecture Summary and Total Cost (FY04$B).

- Dedicated Strategic Lift assets are needed to move a brigade-size force in order to seize the initiative within 10 days. Since expeditionary forces are our nation's first responders, it is important that they arrive as early as possible during a crisis so they can control the initial phases of hostilities and influence subsequent courses of action. Seizing the initiative encompasses the Closure and Employment phases. Specific capability gaps include the transport of non-self-deploying aircraft (NSDA) to the Sea Base, especially aircraft that must be disassembled for transport and subsequently reassembled. The additional time required for the Air Mobility Command (AMC) to plan, coordinate, and establish an air bridge to transport the NSDA and all nonprepositioned equipment to the FLS degrades the performance of the 2015 BLA and Alternative Architecture I as shown in Figure 1. This delay is not present in Alternative Architectures II or III since they incorporate dedicated strategic lift assets to improve their performance.

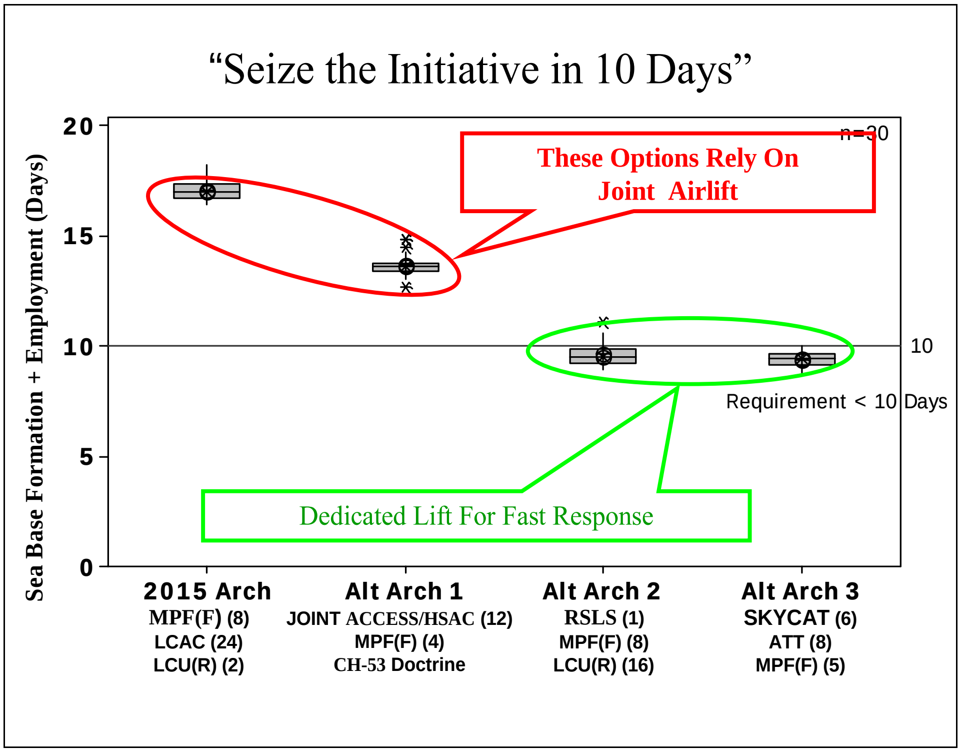

Figure 1: Dedicated lift is required to seize the initiative within 10 days.[2]

- Rapid force employment is hindered by multiple at-sea transfers. The Employment Phase is defined as the elapsed time to complete the insertion of the 2 surface and 1 vertical BLTs. Relatively small craft, such as the Landing Craft, Air Cushion (LCAC) vehicle and even the Heavy Lift LCAC (HLCAC) vehicle, require multiple at-sea transfers in order to load vehicles during the Employment Phase. These transfers are time-consuming, even under ideal conditions, and may be impossible in heavy seas. Large assault connectors, such as the Landing Craft Utility, Replacement (LCU(R)) and the Joint ACCESS, designed by students in the TSSE Group, are beneficial in that they reduce the number of at-sea transfers and improve architecture performance during the Employment Phase. Each of the three alternative architectures in Figure 2

[2] HSAC is High Speed Assault Craft. RSLS is Rapid Strategic Lift Ship. ATT is Advance Theater Transport.

incorporates a large assault connector, enabling them to outperform the 2015 BLA.

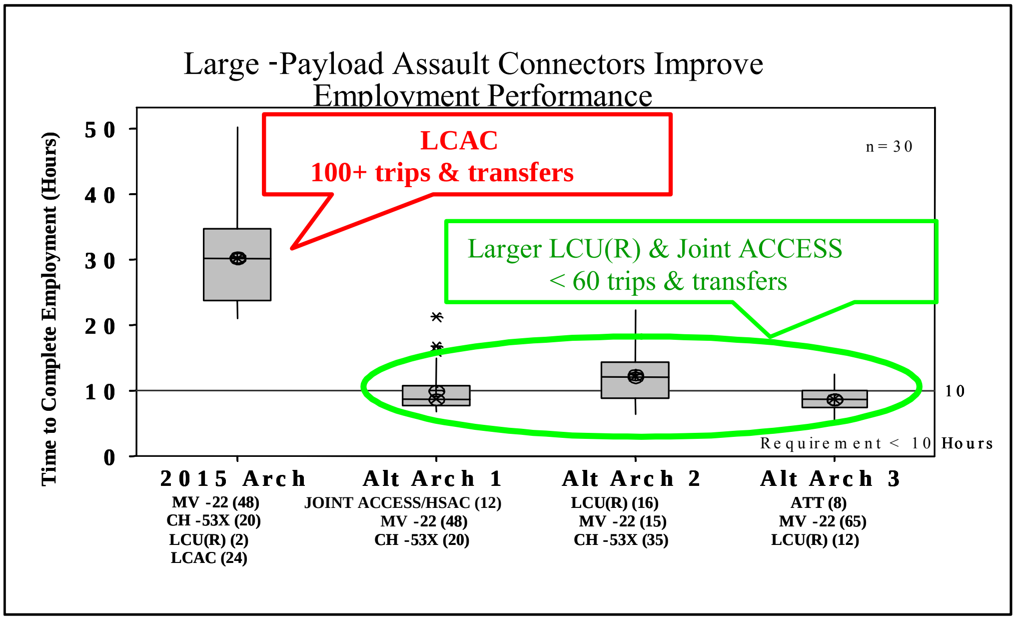

Figure 2: Large-payload craft reduce at-sea transfers.

The 2015 architecture uses LCAC as its primary assault connector and requires 127 total trips and transfers (loading and unloading). Alternative Architecture II and Alternative Architecture III use the larger LCU(R) and average 50-60 trips to insert the two surface BLTs. Alternative Architecture I utilizes 12 preloaded Joint ACCESS vessels, which are able to off-load the 2 surface BLTs with no additional at-sea transfer. The large-payload Joint ACCESS and the LCU(R) yield fewer trips, which eliminate or reduce the at-sea transfer accompanying each trip.

- Future nonmateriel proposals look promising. Reassembling the CH-53 aircraft while en route to the Sea Base reduces the time required to complete the Closure phase. Additionally, a simple change in the type of air asset utilized for Medical Evacuation (MEDEVAC) lift addresses a gap in capability for the Sea Base to provide advanced medical care within 1 hr during the Sustainment phase. In order to increase the probability of

survival following massive trauma, the 2015 BLA uses the UH-1Y as the primary MEDEVAC platform, while each of the three alternative architectures utilize the MV-22. As illustrated in Figure 3, each of the alternative architectures performs significantly better than the 2015 BLA.

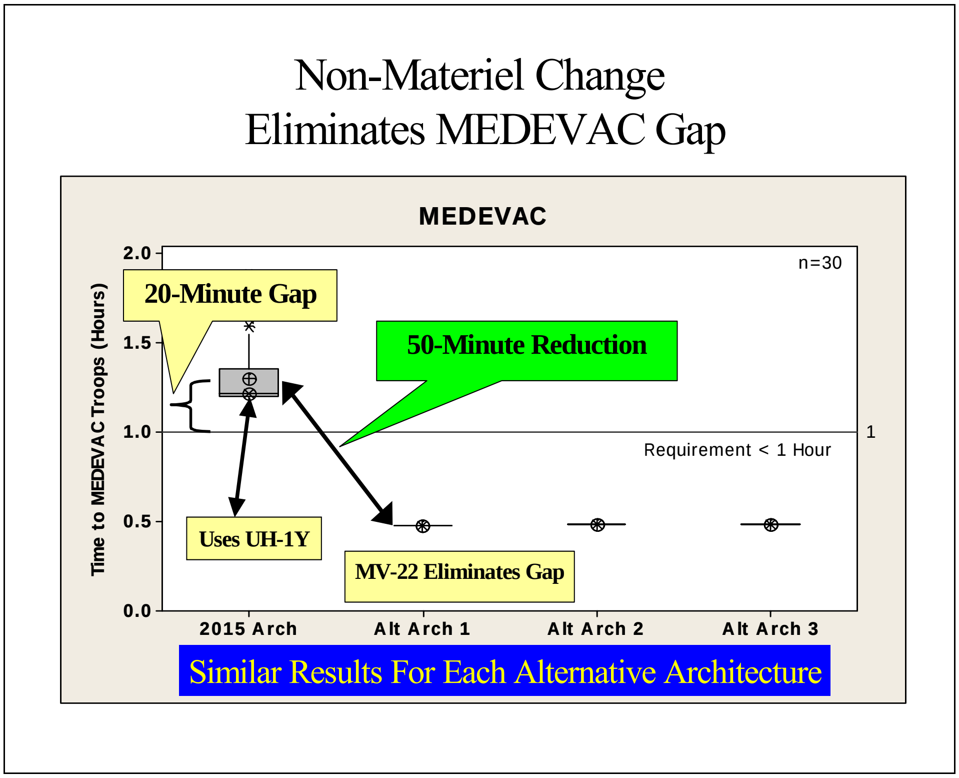

Figure 3: Nonmateriel change eliminates MEDEVAC gap.

- Future materiel proposals look promising. Dedicated strategic lift assets, such as high-speed surface ships (Rapid Strategic Lift Ship) and lighter-than-air ships (SkyCat™ 1000), may provide an answer to the capability gaps identified in the Closure Phase. In order to allow the expeditionary forces to seize the initiative within 10 days, the Closure Phase must be completed within 9.6 days (10 days minus 10 hrs to complete the Employment Phase). Figure 4 shows that reliance on nonorganic strategic lift assets results in a gap of at least six days. Transporting the NSDA to the FLS is the primary cause of this performance shortfall.

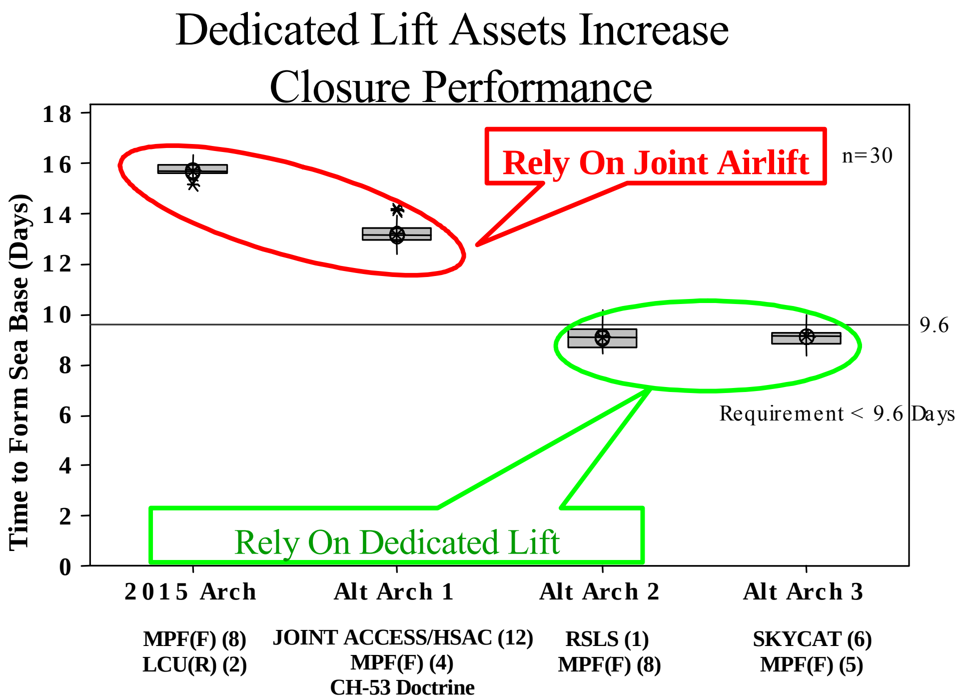

Figure 4: Dedicated lift assets increase Closure Phase performance.

Other key findings include:

- A near real-time asset-visibility system is critical in order to avoid building a large stockpile of supplies at the objective ashore.

- A majority of the operating air deck spots in the Sea Base are needed to sustain troops at the objective (few spots remain for nonlogistical missions).

- The MV-22 is best suited for troop transport. Its benefits diminish when used for cargo resupply or when the mission radius is greater than 150 NM (in the external lift mode, the MV-22 is much less capable of resupply than the CH-53).

SEA-6 recommends further study efforts in the form of a detailed survivability analysis of the MPF(F), and a survivability and reliability analysis of the alternative connectors used in this study. Further study and experimentation is also warranted to

investigate and measure tactical at-sea transfer performance for lighterage and Integrated Landing Platforms (ILPs) under various sea states. Additionally, a Unified Expeditionary Command concept, vis-à-vis Special Forces Command (SOCCOM), or other alternative command structures, should be explored in conjunction with a conceptual design for Sea Base Common Logistics Picture (CLP) architecture.

The 2004 Seabasing and JELo Integrated Project is an academic exercise and is not endorsed by either the Navy or any other U.S. military service. Examining Seabasing and JELo in its entirety is extremely challenging. The regional conflict and near-peer competitor scenarios are used to facilitate analysis and do not represent official views or policies of the Navy or any government. Although all elements of Seabasing and JELo are not evaluated to the greatest extent possible, they are evaluated to the extent practical, given the time available for the study. SEA-6 nonetheless concludes that the results are informative and provide insights to a decision-maker involved in addressing the complex issues associated with this topic.

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1. INTRODUCTION

1.1 Background

This section presents the guidance Systems Engineering and Analysis (SEA) Cohort Six (SEA-6) received for its campus-wide integrated project. It also sets the stage for the remainder of the Technical Report.

1.1.1 Project Assignment

Early in 2004, the faculty of the SEA curriculum requested project inputs from the Office of the Deputy Chief of Naval Operations for Warfare Requirements and Programs (OPNAV N7). In April 2004, OPNAV N7 tasked the Wayne E. Meyer Institute of Systems Engineering to conduct a study on Joint Expeditionary Logistics. The Wayne E. Meyer Institute assigned this study to SEA-6 as a campus-wide integrated project. OPNAV N7 specifically tasked the Wayne E. Meyer Institute for Systems Engineering to "examine Expeditionary Warfare Logistics and associated platforms and systems."[3]

The study's initial objective to analyze "logistics flow to, within and from the Sea Base in a joint warfare environment."[4] The SEA-6 study is the third follow-on study from Systems Engineering and Integration Cohort Three's (SEI-3) study on *Expeditionary Warfare*. SEI-3 used a "system of systems" approach to analyze and engineer architectures to execute ship to objective maneuver (STOM) in the littoral.[5] The two other studies by Systems Engineering and Analysis Cohort Four (SEA-4) and Systems Engineering and Analysis Cohort Five (SEA-5) address *Force Protection of the Sea Base* and *Maritime Dominance in the Littorals*, respectively.

The SEA-6 study's primary objective is to examine the possibilities for delivering and sustaining an expeditionary brigade-sized force at an objective within the 10/30/30

[3] OPNAV N7, Expeditionary Warfare Logistics Study, (Unpublished Memorandum: 2004).
[4] Ibid.
[5] Systems Engineering and Integration Cohort Three, "Expeditionary Warfare," (Unpublished Research Paper, Naval Postgraduate School, Monterey, CA: 2002).

construct. The 10/30/30 construct calls for the expeditionary forces to seize the initiative within 10 days, achieve the expeditionary objectives within 30 days, then reconstitute and redeploy within the next 30 days. The study examines combinations of current systems, systems of record, and other proposed systems out to the year 2025. Proposed systems are primarily limited to Advanced Concept Technology Demonstrations (ACTDs) and Advanced Concept Demonstrations (ACDs). The study occurs from June to December 2004 and partially fulfills SEA-6's requirements for a Masters of Science Degree in Systems Engineering.

1.1.2 Logistics Definition

"Logistics comes from the Greek word *λοχιστικοσ* (logistikos), meaning skilled in calculation."[6] Today the Department of Defense (DOD) defines logistics as:

The science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, those aspects of military operations that deal with:

a. design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of materiel;
b. movement, evacuation, and hospitalization of personnel;
c. acquisition or construction, maintenance, operation, and disposition of facilities; and
d. acquisition or furnishing of services.[7]

The science of logistics dominates today's society. Examples range from going to the supermarket to buy groceries to having a package delivered from a favorite online shopping Website. The civilian sector has improved and streamlined its logistic systems because these systems affect company profits.

[6] David Olwell and David Schrady, OS 4580 Logistics Systems Analysis, course notes (unpublished, September 2003), pp. 7-27.
[7] Defense Technical Information Center, "logistics," DOD Dictionary of Military Terms, n.d., <http://www.dtic.mil/doctrine/jel/doddict/data/l/03104.html> (23 September 2004).

1.1.3 Logistics Importance

"Amateurs discuss strategy; professionals study logistics."
-Anonymous

The annals of military history are filled with examples of how logistics have influenced military operations both positively and negatively. Recent conflicts such as Operation Desert Shield/Storm and Operation Iraqi Freedom highlight logistics' importance in successfully conducting operations. In these U.S.-led Operations, two critical vulnerabilities[8] are identified: the requirement to establish an "Iron Mountain" and the denial of access for basing. These two vulnerabilities are logistical vulnerabilities that, historically, have greatly influenced U.S. military operations.

1.1.4 The Iron Mountain

In Operation Desert Shield/Storm, the Commander-in-Chief Central Command (now Combatant Commander), General Norman Schwarzkopf, ordered 60 days of Class I (Subsistence) and Class V (Ammunition), and 30 days of the remaining supply classes be brought into the Central Command area of responsibility (AOR) to support the operation. Table 1-1 shows the classes of supply. Table 1-2 shows the numbers of people and equipment in the Allied order of battle (OOB) that required logistical support for the ground and air component of Operation Desert Storm.

[8] Critical Vulnerabilities – weakness (and sometimes strengths) that are open to the enemy's attack or can be exploited by the enemy. Milan N. Vego, "Operational Warfare," (Newport: Naval War College Press, 2000), p. 636.

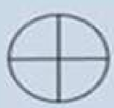
CLASSES	SYMBOLS	SUBCLASSES
Class I - Subsistence		A - Nonperishable C - Combat Rations R - Refrigerated S - Other Nonrefrigerated W – Water
Class II - Clothing, Individual Equipment, Tools, Admin. Supplies		A - Air B - Ground Support Materiel E - General Supplies Supplies F – Clothing G - Electronics M - Weapons T - Industrial
Class III - Petroleum, Oils, Lubricants		A - POL for Aircraft W - POL for Surface Vehicles P - Packaged POL
Class IV - Construction Materials		A - Construction B – Barrier
Class V - Ammunition		A - Air Delivery W – Ground
Class VI - Personal Demand Items		
Class VII - Major End Items: Racks, Pylons, Tracked Vehicles, Etc.		A - Air B - Ground Support Materiel D - Admin. Vehicles G - Electronics J - Racks, Adaptors, Pylons K - Tactical Vehicles L - Missiles M - Weapons N - Special Weapons X - Aircraft Engines
Class VIII - Medical Materials		A - Medical Materiel B - Blood / Fluids
Class IX - Repair Parts		A - Air B - Ground Support Materiel D - Admin. Vehicles G - Electronics K – Tactical Vehicles L - Missiles M - Weapons N - Special Weapons X - Aircraft Engines
Class X - Material For Nonmilitary Programs	CA	

Table 1-1: Classes of Supply.[9]

[9] Global Security.org, "Classes and Subclasses of Supply," 29 September 2002, <http://www.globalsecurity.org/military/intro/supclass.htm> (15 November 2004).

Allied OOB 01 December 1990	
Allied Personnel	
Armed Forces Total Strength	1,110,000
Allied Ground OOB	
Ground Force Equipment	27,350
Allied Air OOB	
Air Assets	3,262

Table 1-2: Operation Desert Shield Ground and Air Allied OOB.[10]

Supporting this vast number of personnel and equipment meant stockpiling items in Saudi Arabia. This supply stockpile is referred to as the "Iron Mountain." Post-war analysis shows that Allied forces did not require as much of the "Iron Mountain" as originally forecast. For example, the United States Air Force sent 350,000 tons of ordnance into the AOR and around 69,000 tons of it was actually used. The remaining amount (some 80% of the total accumulated) was shipped out at the conclusion of the operation.[11] The "Iron Mountain" is considered a critical vulnerability because the supplies provide the enemy an easy target of opportunity for attack and limit mobility.

1.1.5 Denial of Access

In the fall of 2002, members from the European Command (EUCOM) "…had been in close consultation with the Turkish armed forces and civilian leadership…,"[12] to base Allied Forces, specifically the Fourth Infantry Division (4th ID), on Turkish soil to launch an attack on Iraq from the north. As ships containing the 4th ID's equipment appeared off the Turkish coast and requested permission to enter port to off-load cargo, the Turkish government "…refused to allow offensive operations from its soil."[13] The ships containing the equipment bound for Turkey waited for a decision off the Turkish coast. Negotiations between Turkey and the United States did not resolve the issue and when hostilities began, Commander Central Command, General Tommy Franks, ordered

[10] Global Security.org, "Operation Desert Storm," Operation Desert Storm, 19 September 2004, <http://www.globalsecurity.org/military/ops/desert_storm-orbat.htm> (24 September 2004).
[11] Foss, John W. [GEN, USA, Ret.]. "Challenge for Operations Research in the Coming Decade," *Phalanx* (newsletter of the Military Operations Research Society), March 1994.
[12] Gregory Fontenot, E.J. Degen, and David Tohn, "On Point - The United States Army in Operation Iraqi Freedom," *On Point*, n.d., <http://www.globalsecurity.org/military/library/report/2004/onpoint/ch-2.htm#deployment> (23 September 2004).
[13] Ibid.

the ships and the 4th ID to transit the Suez Canal and proceed to Kuwait. The operational plan (OPLAN) was altered and Iraq was only attacked from Kuwait in the south. Turkey's refusal to allow forces to begin operations from inside the Turkish borders exposed another critical vulnerability for the United States—its reliance on foreign access to support military operations.[14]

1.1.6 Critical Vulnerabilities

The Navy's Sea Power 21 transformation involving Seabasing is part of the United States military's vision to convert the critical vulnerabilities of the "Iron Mountain" and the denial of access into a center of gravity.[15] In June 2002, the Chief of Naval Operations (CNO), Admiral Vern Clark, unveiled Sea Power 21 as the Navy's strategy for the twenty-first century. Sea Power 21 is comprised of three primary pillars: Seabasing, Sea Shield, and Sea Strike, all of which are shown in Figure 1-1.

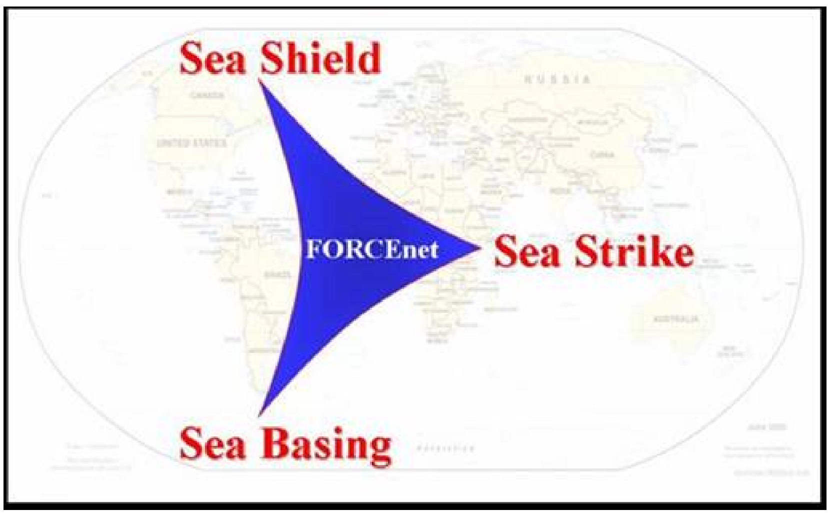


Figure 1-1: Sea Power 21.[16]

[14] The original OPLAN called for a two-pronged attack, with the 4th ID and certain air assets attacking from Turkey in the north and the remainder of the forces attacking from Kuwait in the south.
[15] Center of Gravity – that source of massed strength—physical or moral, or a source of leverage—whose degradation, dislocation, neutralization, or destruction would have the most decisive impact on the enemy's or one's own ability to accomplish a given military objective. Milan N. Vego, "Operational Warfare," (Newport: Naval War College Press, 2000), p. 634.
[16] Admiral Vern Clark, USN, "Naval Institute Proceedings Magazine: Sea Power 21: Projecting Decisive Joint Capabilities," Naval Institute Proceedings Magazine Online, n.d., <http://www.usni.org/PROCEEDINGS/ARTICLES02/proCNO10-2.htm#seabasing> (27 September 2004).

Because current logistics cannot support future concepts of movement and sustainment of a Joint Expeditionary Force (JEF) without reliance upon foreign bases and their infrastructure, Seabasing is recognized as a critical objective. In the CNO's article, he describes Seabasing's[17] impact on the battle space as:

- Pre-positioned warfighting capabilities for immediate employment.
- Enhanced joint support from a fully netted, dispersed naval force.
- Strengthened international coalition building.
- Increased joint force security and operational agility.
- Minimized operational reliance on shore infrastructure.[18]

The last two items aim at resolving the critical logistics vulnerabilities mentioned previously. The fourth item, "Increased joint force security and operational agility," is addressed in SEA-4's integrated project on *Force Protection of the Sea Base*. This addresses the critical vulnerability shown from Operation Desert Shield/Storm that operational agility is increased when there is no burden of an Iron Mountain. The final item, "Minimized operational reliance on shore infrastructure," addresses the critical vulnerability of access denial shown in Operation Iraqi Freedom.

1.1.7 Seabasing Concept

The Seabasing concept was designed:

> "… about placing at sea—to a greater extent than ever before—capabilities critical to joint and coalition operational success: offensive and defensive firepower, maneuver forces, command and control, and logistics. By doing so, it minimizes the need to build up forces and supplies ashore, reduces their vulnerability and enhances operational mobility. It leverages advanced sensor and communications systems, precision ordnance and weapons reach

[17] "Seabasing," a national capability, is the overarching transformational operating concept for projecting and sustaining naval power and joint forces, which assures joint access by leveraging the operational maneuver of sovereign, distributed, and networked forces operating globally from the sea.
Naval Warfare Development Command, "Seabasing SharePoint Site," *Seabasing SharePoint Site*, n.d., <https://nwcportal.nwc.navy.mil/nwdc/sea_basing/> (27 September 2004).

[18] Admiral Vern Clark, U.S. Navy, "Naval Institute Proceedings Magazine: Sea Power 21: Projecting Decisive Joint Capabilities," Naval Institute Proceedings Magazine Online, n.d., <http://www.usni.org/PROCEEDINGS/ARTICLES02/proCNO10-2.htm#seabasing> (27 September 2004).

> while prepositioning joint capabilities where they are immediately employable and most decisive. It exploits the operational shift in warfare from mass to precision and information, employing the 70% of the earth's surface that is covered with water as a vast maneuver area in support of the joint force."[19]

Seabasing is transformational and is intended to change the way the United States conducts military operations. It addresses the critical vulnerabilities of the Iron Mountain and the reliance on foreign basing by having a majority of the logistics associated with an operation at sea under the protection of Sea Shield, thereby reducing the Iron Mountain ashore. Since the Sea Base is in international waters, it will not be constrained by the rules and regulations of foreign nations. To make the Seabasing concept a reality, the military must develop the logistics infrastructure to support this transformational concept.

1.2 Purpose

The purpose of the SEA-6 Technical Report on Joint Expeditionary Logistics (JELo) is to provide the Navy with insight into this important and timely issue and to simultaneously fulfill the project requirements for a Masters of Science Degree in Systems Engineering. Presenting a systems and analytical view of Seabasing and JELo highlights important issues related to achieving the Seabasing vision. The Iron Mountain's critical vulnerabilities and reliance on foreign nations for basing of forces are problems for the United States. The SEA-6 study examines the architectures and systems needed to rapidly deploy and sustain joint expeditionary forces operating from a Sea Base. It identifies the necessary tasks, describes current gaps in required capabilities, and proposes potential approaches to reduce and/or eliminate those capability gaps. SEA-6 expects the study results to provide decision-makers with insights into the potential ways to improve current capabilities and the possibilities for developing new capabilities.

[19] Moore, Charles W., Jr., VADM, USN and Hanlon, Edward, Jr., LTG, USA, "Sea Basing Operational Independence for a New Century," appearing in *Proceedings*, January 2003.

1.3 Scope

Since logistics involves the building, movement, and sustainment of forces, there are numerous areas of Seabasing and JELo upon which it would be appropriate to focus a study. Based on the tasking received, the research conducted, and the six-month time frame with which to complete the study, SEA-6 focuses on the areas believed most important to high-level decision-makers.

The SEA-6 analysis covers the Sea Base's capabilities to support a brigade-sized force performing Joint Forcible Entry Operations (JFEO). Since Seabasing is a primary component of the Navy's transformational concept for projecting and sustaining combat power from the sea, non-Sea Base solutions are not considered. A brigade-sized force is selected based on the CNO's Guidance in the Naval Transformation Roadmap.[20] Although the United States Army (USA) has a description of their envisioned Brigade Combat Team (BCT), much of the associated equipment is still under development and exact sizes and weights cannot be determined. The United States Marine Corps (USMC), however, has published a detailed description of their envisioned expeditionary brigade for the 2015 time frame. Therefore, SEA-6 uses the USMC force numbers as a surrogate for analysis of a Joint Expeditionary Brigade (JEB) throughout the study, with the assumption that minor modifications to these force numbers would produce similar results.

Particular focus is placed on the Seabasing issues revolving around the inter- and intratheater platforms and connectors for both airlift and sealift of forces, equipment, and logistical supplies in the 2015 time frame and beyond to 2025. Systems and platforms are initially limited to those systems and platforms considered Programs of Record during FY 2004 and those that are currently in inventory and expected to remain active through the 2015 time frame. Advanced Concept Technology Demonstrations (ACTDs) and Advanced Concept Demonstrations (ACDs) are the primary materiel considerations for the 2015 to 2025 time frame. Other factors are also addressed, including system

[20] Honorable Gordon England (Secretary of the Navy), ADM Vern Clark (CNO), Gen. James Jones (CMC), "The Naval Transformation Roadmap," July 2002.

reliability, supply consumption rates, sea-state effects, and vertical lift capacity. The analysis is conducted using unclassified source material.

In order to evaluate the logistics process in manageable pieces and put a boundary on the scope of effort, SEA-6 divides the Seabased JELo system operational flow into four functional subsystems: command and control (C2), inventory and storage, connector platforms (both sea and air), and transfer systems (between the connector platforms). Additionally, given the limited time frame and number of personnel to accomplish the study, SEA-6 narrows the scope of the project to the Closure, Employment, and Sustainment phases of Joint Expeditionary Operations. Withdrawal and Reconstitution of forces are considered to be outside the scope for this study. The details of these phases and their associated logistics concepts are described in Chapter 2 [Operating Concept].

1.3.1 Simplifications

Although Seabased combat operations may occur in any of the littoral regions of the world, day or night and in all weather,[21] only weather up to sea state 4 (4-8 ft waves)[22] and sustained winds up to 20 kts[23] are considered in this study.

Carrier Strike Groups (CSGs) are currently resupplied with the existing fleet of Combat Logistics Fleet (CLF) ships. Expeditionary Strike Groups (ESGs) operate independently of external logistical networks. They provide all of the provisions and equipment to the embarked fighting force. Therefore, the logistics needs of these Sea Base platforms are not considered in this study.

Of the logistic commodities classes (I-X) for support of the JEB force and the Sea Base shown in Table 1-1, only food and water (Class I), fuel (Class III), and

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[21] All weather implies rain, snow, ice, reduced visibility, high and low temperatures.
[22] Sea Basing CONOPS, p. 14.
[23] Defense Mapping Agency Hydrographic/Topographic Center, *The American Practical Navigator*, 1995 ed., Defense Mapping Agency Hydrographic/Topographic Center, Bethesda, 1995, p. 535.

ammunition (Class V) are examined since they "make up 98% of the weight of daily replenishment requirements"[24] for operations ashore.

1.4 Methodology

This section reviews the systematic approach SEA-6 uses to conduct its analysis of Seabasing and JELo.

1.4.1 Systems Engineering

There are many systems engineering approaches and processes. A definition that captures the essence of systems engineering originates from the International Council on Systems Engineering (INCOSE). They define systems engineering as:

> Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem:
>
> - Operations
> - Performance
> - Test
> - Manufacturing
> - Cost and Schedule
> - Training and Support
> - Disposal
>
> Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs."[25]

This top-level definition of the systems engineering approach is useful in understanding the overarching principles that guide the systems engineering process, but

[24] Center for Naval Analysis, "Project Culebra: Seabased Combat Service Support for Ship-to-Objective-Maneuver," [CNA CRM 95-144], September 1995, p. 11.
[25] "What is Systems Engineering," available from http://66.34.135.97/whatis.html; accessed on 03 November 2004.

it is not a cookie-cutter approach readily applied in every project. Just as no two projects are exactly alike, no two systems engineering methodologies are exactly alike. The systems engineering approach serves as a guide to the systems engineer and acts as a blueprint to frame a problem so validated "tools" or techniques can guide the design, test and evaluation of the overall system.

1.4.2 Joint Capabilities Integration and Development System

SEA-6 uses the Department of Defense (DoD) Joint Capabilities Integration and Development System (JCIDS) as its systems engineering blueprint to guide the analysis of the Seabased and JELo problem. JCIDS is the current DoD systems engineering framework approved by the Chairman of the Joint Chiefs of Staff to guide the services in system development and acquisition.

The need for JCIDS stems from the traditionally inefficient and costly service-oriented practice of stove-piped acquisition, where single-service system solutions frequently result in a duplication of assets among the services. JCIDS inspires more objective system analysis and joint war fighting needs prioritization. It seeks to transform the services out of the stove-piped acquisition paradigm by providing a methodical process to identify, describe, and prioritize capability gaps. In addition, the JCIDS approach promotes the exhaustion of often over-looked nonmateriel solutions prior to committing to costly materiel acquisition programs.

JCIDS encompasses a structured, four-step methodology that identifies capability needs, capability gaps and approaches to provide capabilities within a specified functional or operational area. The approach is based on national defense policy and is centered on Joint Operating Concepts and current integrated architectures. The analysis enables the development of integrated joint capabilities from a common understanding of existing joint force **d**octrine, **o**rganization, **t**raining, **m**ateriel, **l**eadership and education,

personnel, and **f**acilities (DOTMLPF) capabilities and deficiencies.[26] A depiction of the JCIDS approach is shown in Figure 1-2.

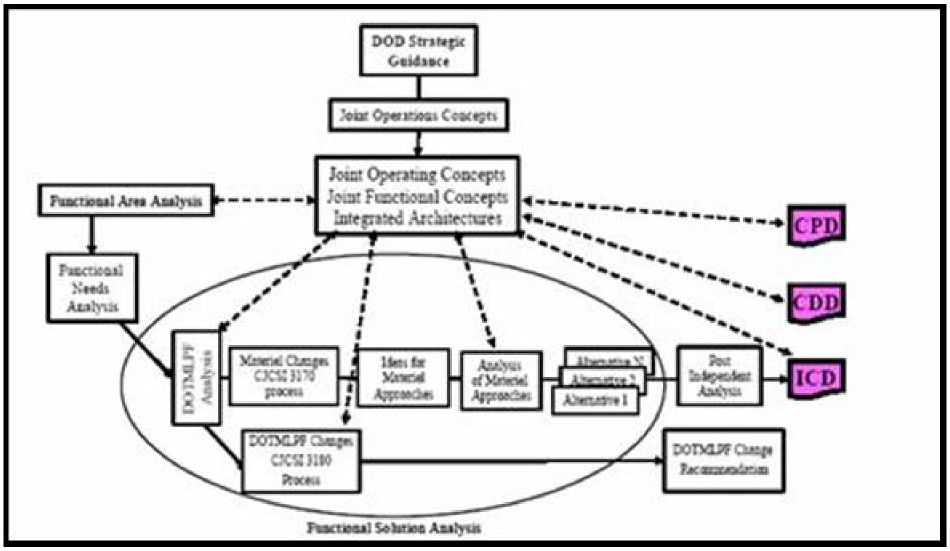

Figure 1-2: Schematic of the DoD JCIDS Systems Engineering Approach.[27]

JCIDS' first step is the Functional Area Analysis (FAA). The FAA identifies the operational tasks, conditions, and standards needed to achieve military objectives. It uses DoD strategic guidance, Joint Operating Concepts, current integrated architectures, and the anticipated broad range of threat capabilities as input. The output of the FAA is the tasks that are reviewed in the follow-on Functional Needs Analysis (FNA).[28]

The second step of the JCIDS approach is the Functional Needs Analysis (FNA). It assesses the ability of current and programmed joint capabilities to accomplish the tasks identified in the FAA, under the full range of operating conditions, and to the designated standards. The inputs to the FNA are the tasks identified during the FAA. The FNA's output is a list of capability gaps or shortcomings that require solutions, as well as the time frame in which those solutions need to be addressed.

The third step of the JCIDS approach is the Functional Solutions Analysis (FSA). This phase is an operationally based assessment of potential DOTMLPF approaches to

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[26] Chairman of the Joint Chiefs of Staff Manual 3170.01D, 12 March 2004, Enclosure A, p. A-1.
[27] Chairman of the Joint Chiefs of Staff Manual 3170.01A, 24 June 2003, Enclosure A, p. A-1.
[28] Ibid., p. A-2.

solving one or more of the capability gaps identified in the FNA phase. The outputs of the FSA phase are potential solutions to fill the gaps identified in the FNA phase. This phase also specifies a priority of solutions in that alternative architecture designs first focus on nonmateriel solutions to narrow or close the capability gaps to prevent unneeded and costly new materiel starts. Existing product improvements are the next priority, with costly and time-consuming new materiel acquisition programs as a last resort.[29]

The final phase of the JCIDS analysis approach is the Post Independent Analysis. In this phase, the sponsor considers the compiled information and analysis results to determine which integrated DOTMLPF solution best addresses the joint capability gap in the functional area.[30] This final JCIDS phase is out-of-scope for the SEA-6 project and is left to the project sponsors for their consideration.

1.4.3 SEA-6 Approach

The JCIDS framework satisfies both the classical systems engineering process, as well as the unique DoD transformational need to improve interoperability and to exhaust nonmateriel solutions prior to implementing unneeded, costly and time-consuming materiel ones. The classical systems engineering process maps directly to the four-step JCIDS process as depicted in Figure 1-3.

[29] Ibid.
[30] Ibid.

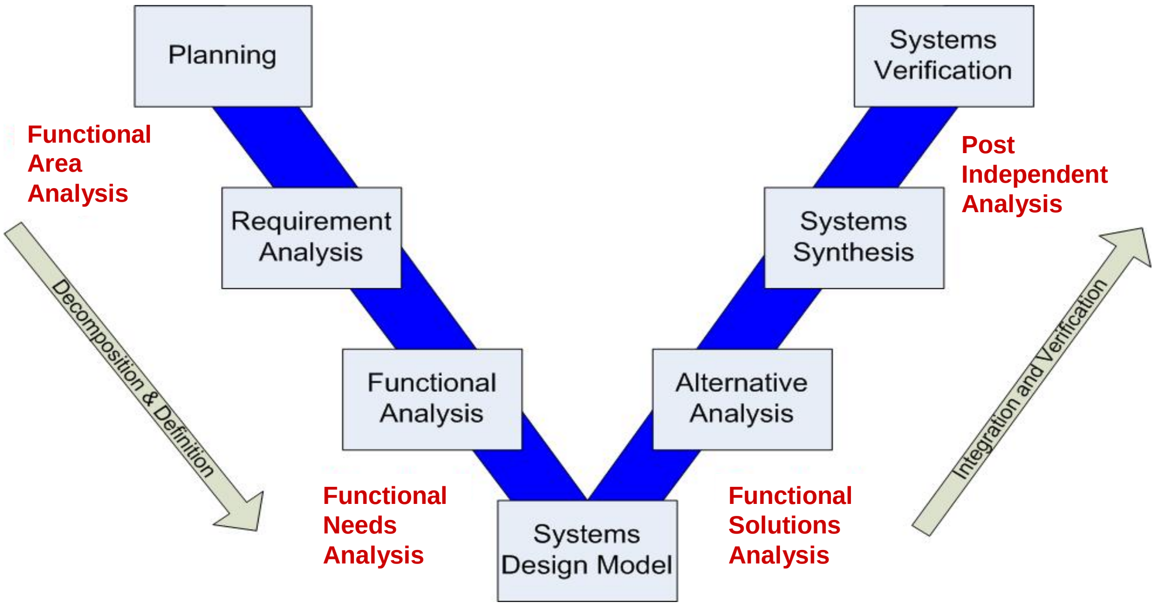

Figure 1-3: Mapping the Classical Systems Engineering Process to the Four-Step JCIDS Process.

In the past, many SEA and DoD projects have focused on materiel acquisition solutions and failed to explore the significant amount of trade space that the additional nonmateriel analysis makes available. The recent DoD change in systems engineering toward JCIDS analysis permits SEA-6 to explore the additional nonmateriel trade-space and focus on both materiel and nonmateriel centric alternative solutions to fill capability gaps. SEA-6 views the JCIDS approach as an extension of the classical systems engineering process and one that is tailored toward enhancing joint military operations. In the military environment, a materiel solution alone is insufficient to define an architecture or to create a complete war fighting solution. Synchronization across the DOTMLPF spectrum is required to provide a balanced, cost-effective, and reliable war-fighting system. SEA-6 uses the JCIDS with the system engineering process depicted in Figure 1-4 as a framework for the Seabasing and JELo study.

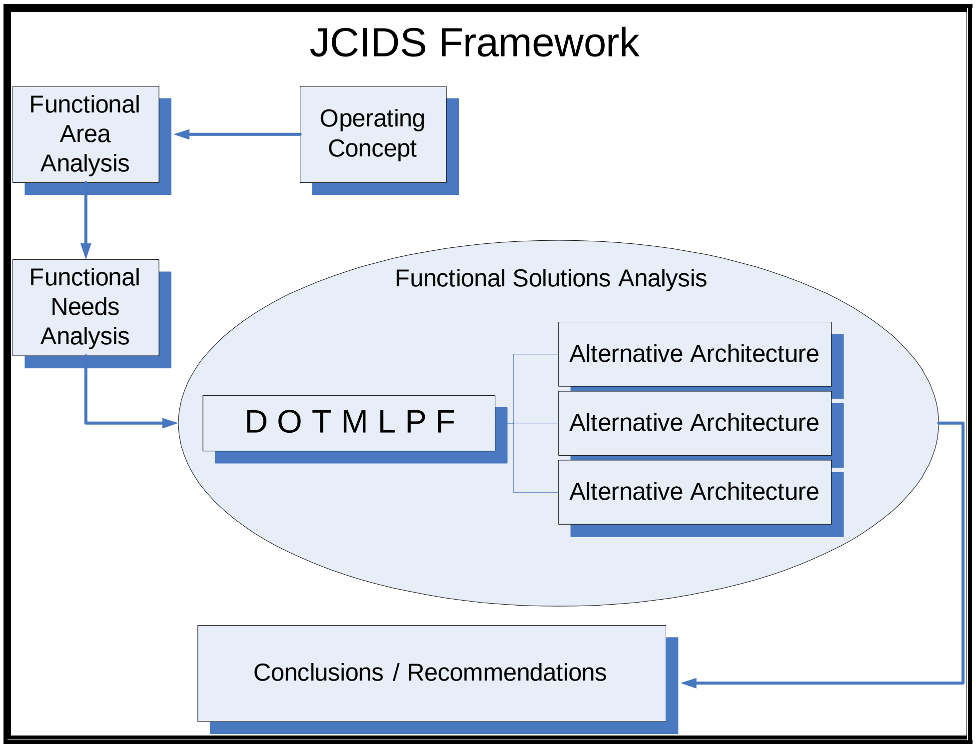

Figure 1-4: Flowchart of the SEA-6 JCIDS Framework.

1.4.4 Program Management Plan

The first phase of the SEA-6 project is one of problem definition and organization into a team-of-teams that focuses toward a common goal. Aiding SEA-6 in this endeavor is the JELo Project Management Plan (PMP). The PMP defines the JELo tasking, problem definition, scope, system boundaries, and initial program assumptions and constraints. It further defines program deliverables, quality assurance, and acts as a risk mitigation tool by which schedule risk may be evaluated against the budgeted work breakdown structure.

An additional role of the PMP is to depict both the SEA-6 external and internal team organization. The Seabasing JELo problem is complex and collaborative partnerships with external research teams is essential for successful project completion. A list of collaborative partnerships for the SEA-6 Seabasing JELo project is found in Table 1-3.

External Partnership	Location	Level of Effort
Total Ship Systems Engineering (TSSE)	Naval Postgraduate School (NPS), Monterey, CA	Design of an alternative solution High Speed Assault Connector.
N703 (CDR Mark Becker)	Pentagon, VA	Responsible for the Seabasing Transformation Roadmap. Share ideas with SEA-6 concerning Sea Base Operating Concept (OPSCON). Parallel effort to determine the most effective mix of Sea Base components, interfaces, and operations. Main focus on major theater of war scenarios vice small-scale operations. Using Extend™ to develop a Sea Base simulation.
N42 (LCDR Futcher)	Crystal City, VA	Share ideas with SEA-6 concerning the Sea Base Logistics CONOPS.
Marine Corps Combat Development Command (MCCDC)	Quantico, VA	Supporting information on 2015 Marine Expeditionary Brigade components and operations.
Naval Research Advisory Committee (NRAC)		Share preliminary findings concerning capability gaps. Review of NRAC Seabasing study for the Assistant Secretary of the Navy for Research and Development (ASN (RD&A)).
Naval Sea Systems Command (NAVSEA) (Mr. Jeff Koleser)	Carderock, MD	Parallel analysis of the Seabasing JELo problem with specific focus on generating operational requirements for connector and transfer systems. Share ideas and data concerning at-sea, skin-to-skin transfer mechanisms. Using Extend™ to develop a Sea Base simulation.
Naval Sea Systems Command (NAVSEA) (Mr. Steve Wynn)	Carderock, MD	Supporting cost data and performance specifications for the Rapid Strategic Lift Ship (RSLS).
NSWC Pt. Hueneme (Mr. Marvin Miller)	Pt. Hueneme, CA	Supporting information on connected replenishment and skin-to-skin transfer programs and technologies.
NDIA-Sea Viking 2004 War Game	Quantico, VA	Sea Viking 04 (SV04), a two-week U.S. Joint Forces Command and Marine Corps experiment examining how to best project joint force power ashore relying heavily on a joint Sea Base.
Center for Naval Analysis (CNA)		Maritime Prepositioning Force (Future) (MPF(F) Analysis of Alternatives Study.
Operations Research Department War Game (LTC Saverio Manago)	NPS, Monterey, CA	Participation to gain a different perspective on the performance of the 2015 Baseline Architecture based on man-in-the-loop simulation.
Air Force Institute of Technology (AFIT)	Dayton, OH	SEA-6 generation of operational requirements for AFIT design of Joint Air Operations Center (JAOC).
TRADOC Analysis Center (TRAC)-Monterey	NPS, Monterey, CA	Supporting information for Army BCT.
Operations Research Department (LtCol Greg Mislick)	NPS, Monterey, CA	Supporting information for cost estimation and analysis.
Information Systems Department (Prof. Rex Buddenberg)	NPS, Monterey, CA	Supporting information for command and control system composition and analysis.

Table 1-3: SEA-6 External Team Collaborative Partners.

External team relationships are important since they define the chain-of-command and hierarchal relationships of the integrated and collaborative

partnership teams. The hierarchal relationship diagram governing the SEA-6 JELo collaborative partnerships is depicted in Figure 1-5.

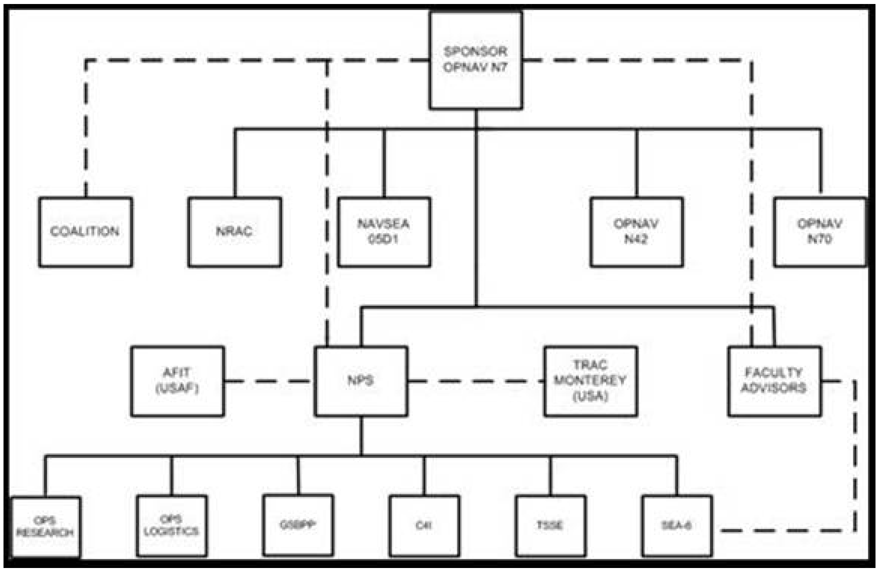

Figure 1-5: SEA-6 JELo Collaborative Partnership Hierarchal Chart.

Internal team organization and alignment is also a top priority in order to meet milestone requirements. A literature review of prior studies and an analysis of alternatives suggest that the most critical JELo functional areas contributing to capability gaps correspond to the following functional subsystems:

1. Command and control.
2. Inventory and storage management.
3. Transfers at nodes between transportation connectors.
4. Point-to-point transportation connectors.

SEA-6 utilizes a competency-aligned organizational structure to build subject matter expertise along these subsystem functional areas. This competency alignment provides the backbone for the organization of the SEA-6 Team. Integrated product teams (IPTs) are developed to form a matrix organization to tackle specific tasks across the core competency functional areas. This competency aligned organization is envisioned to form the structure depicted in Figure 1-6. The command and control team serves as the

foundation for the JELo system and the other three functional teams form the support pillars that enable JELo performance.

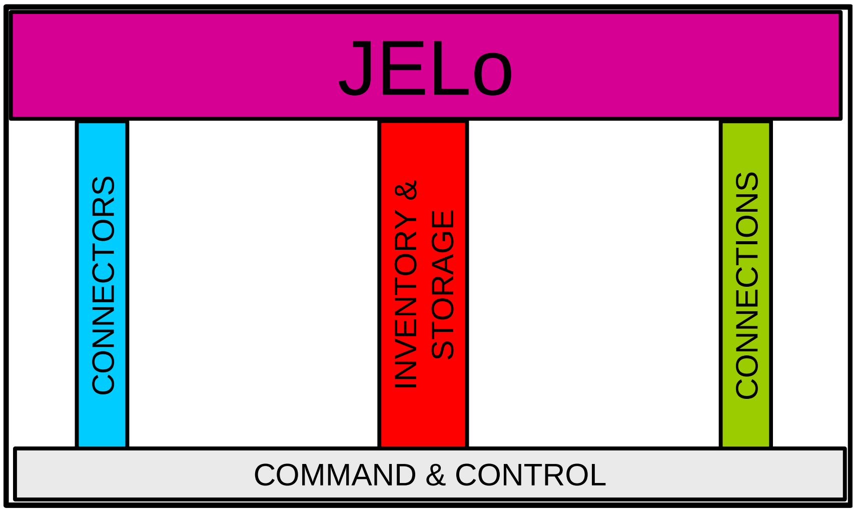

Figure 1-6: SEA-6 Project Team Internal Competency Alignment Organization.

1.4.5 Operating Concept

The first step in JCIDS is the Functional Area Analysis (FAA). However, before the FAA can begin, one important question must be answered: "What do we want the system to accomplish?" Answering this question requires research into published DoD strategic guidance concerning military objectives (i.e., Quadrennial Defense Review, Defense Planning Guidance, National Security Strategy of the United States, Joint Vision 2020, etc.). Other resources include the published Joint Operational Concepts (JOC), as well as planned integrated architectures. Since much of the information for Seabasing and JELo is ill defined for the 2025 time frame, SEA-6 authored an Operating Concept to postulate its view of these operations in one coherent document. The SEA-6 Operating Concept [Chapter 2] captures the general nature of operations independent from the level of war and enables the generation of traceable high-level mission requirements in the follow-on FAA.

1.4.6 Functional Area Analysis

The FAA [Chapter 3] answers the question, "What needs to be done?" It defines the tasks, conditions, and standards for Seabasing and JELo and draws on the SEA-6

OPSCON to provide the strategic and operational construct for the problem. The output of the FAA is a list of Seabased JELo tasks derived from the Universal Joint Task List (UJTL) and a corresponding list of conditions and standards for each task. These tasks, conditions and standards collectively form the operational requirements for the Seabased JELo system. Design requirements from this analysis are furnished to the Naval Postgraduate School's Total Ship Systems Engineering curriculum for their collaborative design effort. Additionally, these requirements are used in the design of the 2015 Baseline Architecture [Chapter 5].

1.4.7 Functional Needs Analysis

The primary purpose of the Functional Needs Analysis (FNA) [Chapters 4-11] is to evaluate a current or planned integrated architecture against the requirements generated in the FAA to identify any potential capability gaps. The FNA helps answer the question, "What capability gaps exist between what we have now and what capabilities we will have with proposed future improvements?" SEA-6 uses current (2004) Programs of Record to establish a 2015 Baseline Architecture for Seabasing and JELo operations. The SEA-6 Team uses a trade study, analysis of alternatives, and literature review to select from existing systems and programs of record to form the 2015 Baseline Architecture.

SEA-6 then uses a simulation model to identify and quantify potential capability gaps of the 2015 Baseline Architecture. The simulation model is designed as an extensible, parameterized model to simulate not only the 2015 Baseline Architecture, but also to accommodate the evaluation of alternative architecture designs. A design of experiments is used to plan an efficient data collection effort. Operational requirements generated in the FAA phase are used to formulate critical operational issues (COIs), measures of effectiveness (MOEs), and measures of performance (MOPs) to evaluate system performance.

A SEA-6 threat-based capability study results in the development of an operational scenario to judge system performance under realistic and expected

environmental and combative conditions. Scenario effects are captured in the input variables of the simulation model to evaluate JELo system performance. Additionally, a collaborative war game with the Naval Postgraduate School's Operations Research Department is conducted to gain a different perspective on the performance of the 2015 Baseline Architecture based on man-in-the-loop simulation. The cost of the 2015 Baseline Architecture is also estimated to provide a baseline for future cost-benefit decisions concerning follow-on alternative architectures.

1.4.8 Functional Solution Analysis

The Functional Solution Analysis (FSA) [Chapters 12-13] is the third and final phase of the SEA-6 systems engineering project. The FSA helps answer the question, "How can we close or reduce the capability gaps?" The Seabasing and JELo system capability gaps identified in the FNA are used as inputs for the design of alternative architectures. The output of this phase includes designs of alternative architectures intended to close or reduce the capability gaps previously identified in the FNA. Additionally, the costs of these alternative architectures are estimated for comparison with the 2015 Baseline Architecture.

SEA-6 divides into three competing design teams utilizing the DOTMLPF trade space to design alternative architectures for the 2025 time frame. A sensitivity analysis of the JELo simulation model parameters is conducted to gain insight into the Seabasing and JELo system architecture component performance sensitivities enabling design teams to focus toward specific, high-impact DOTMLPF changes. Alternative architectures are also subjected to the same scenario in the simulation model as the 2015 baseline, facilitating a side-by-side comparison. This pair-wise comparison allows identification of any statistical or militarily significant performance gains and/or reductions in capability gaps realized by the alternative architecture designs.

2. OPERATING CONCEPT

2.1 Overview

This Operating Concept describes Systems Engineering and Analysis Cohort Six's (SEA-6's) postulated view of Joint Expeditionary Operations (JEO) and the associated Joint Expeditionary Logistics (JELo) in the 2025 time frame. Emphasis is on full integration, where all aspects of United States-led military power are fused and synchronized and accommodate one or more allied partners.[31] JEO can be considered in phases: Pre-Deployment, Closure, Employment, Sustainment, Withdrawal, and Reconstitution. The SEA-6 Operating Concept is intended to describe the entire operation: 1) Pre-Deployment, 2) the application of military power until objectives are reached, and 3) the withdrawal and redeployment of that military power. Figure 2-1 depicts this operating concept.

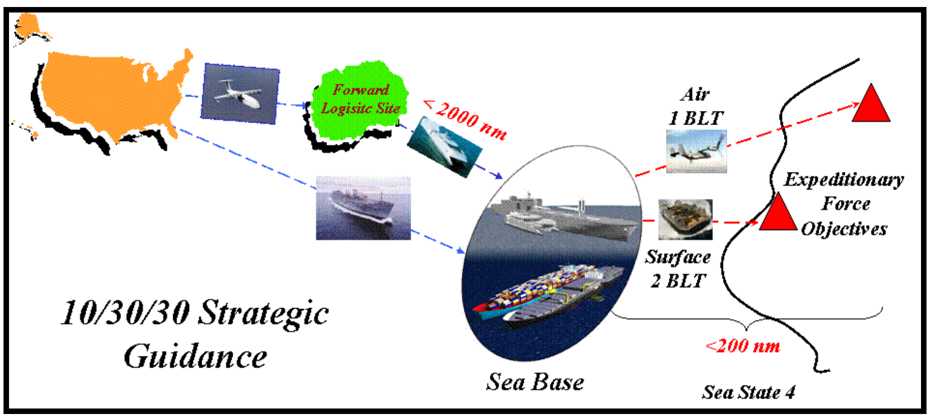

Figure 2-1: Joint Expeditionary Operations.

The Expeditionary Forces seize the initiative within 10 days, achieve the expeditionary objectives within 30 days, then reconstitute and redeploy within the next 30 days. The Expeditionary Logistics systems meet the demand of the Combined Task Force Commander (CTF CDR) without creating an operational pause.

JEO apply to the full spectrum of conventional conflict whether against a Non-state Actor or a Near-Peer Competitor. Mission capabilities range from

[31] Chairman of the Joint Chiefs of Staff, National Military Strategy, 2004, p. 7.

Presence/Deterrence Operations to Major Combat Operations just short of Strategic Nuclear War, as shown in Figure 2-2.[32]

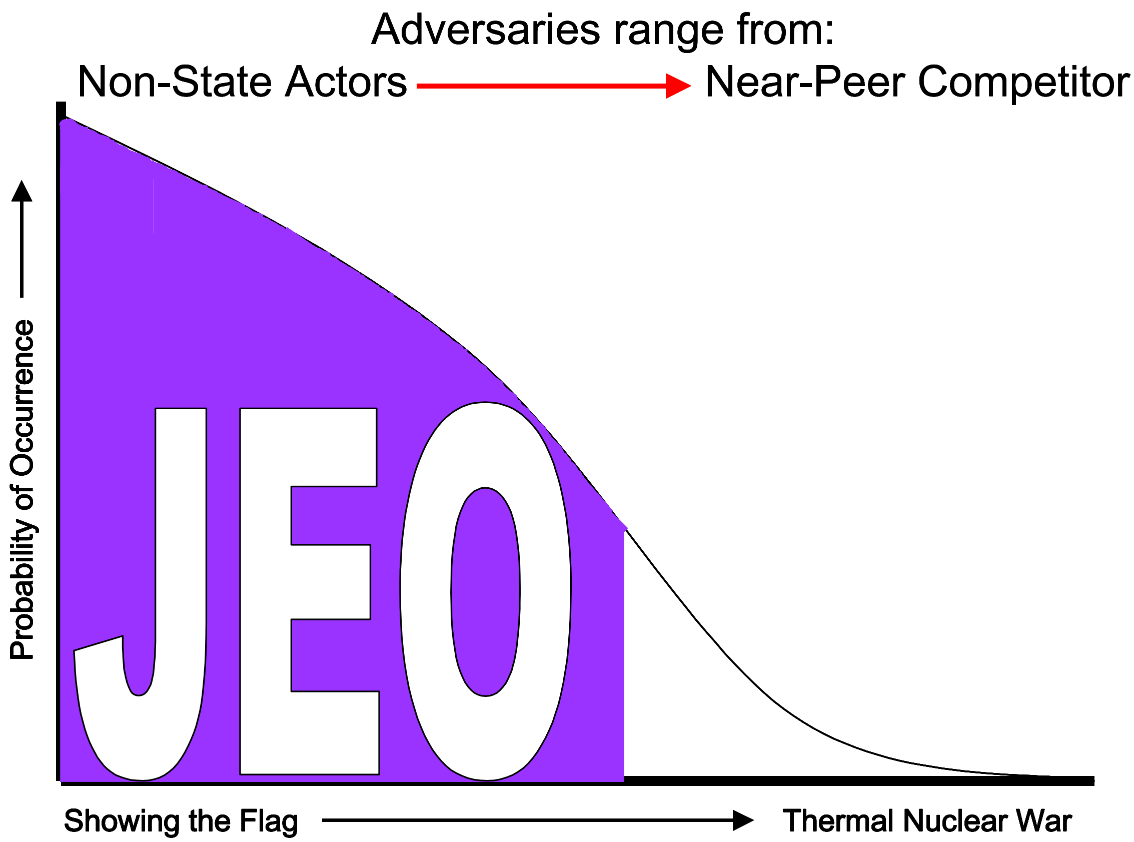

Figure 2-2: Spectrum.

These operations may occur in any of the littoral regions of the world, day or night, all weather,[33] up to sea state 4 (6-8 ft. waves)[34] and sustained winds up to 20 kts.[35] The Area of Operations (AO) and objectives are in a geographic location where conventional access (road/rail, neighbor over flight, and/or permissive port/airfield facilities) is not available. The objectives may be at sea, on land, in the air, in space, or in

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[32] OPNAV N703, *Sea Basing Concept of Operations (CONOPS)*, *DRAFT*, unpublished PowerPoint brief, 11 March 2004, p. 10.

[33] All weather implies rain, snow, ice, reduced visibility, high and low temperatures.

[34] Sea Basing CONOPS, p. 14.

[35] Defense Mapping Agency Hydrographic/Topographic Center, *The American Practical Navigator*, 1995 ed., Defense Mapping Agency Hydrographic/Topographic Center, Bethesda, 1995, p. 535.

cyberspace. Power is projected and sustained from a Sea Base in crises or conflicts where a Sea Base adds combat capability.[36]

2.2 Planning

Although some situations may be preplanned, expeditionary implies rapid response using Crisis Action Planning procedures.[37] As such, the CTF may be forming and planning while the expeditionary forces are en route to the AO.

2.3 Pre-Deployment Phase

The Pre-Deployment Phase describes the configuration and disposition of the Expeditionary Forces (EXFORCES), shown abstractly in Figure 2-3 with no preexisting connections. Since JEO applies at the operational level of war, the situation is described in terms of Space, Force, and Time.

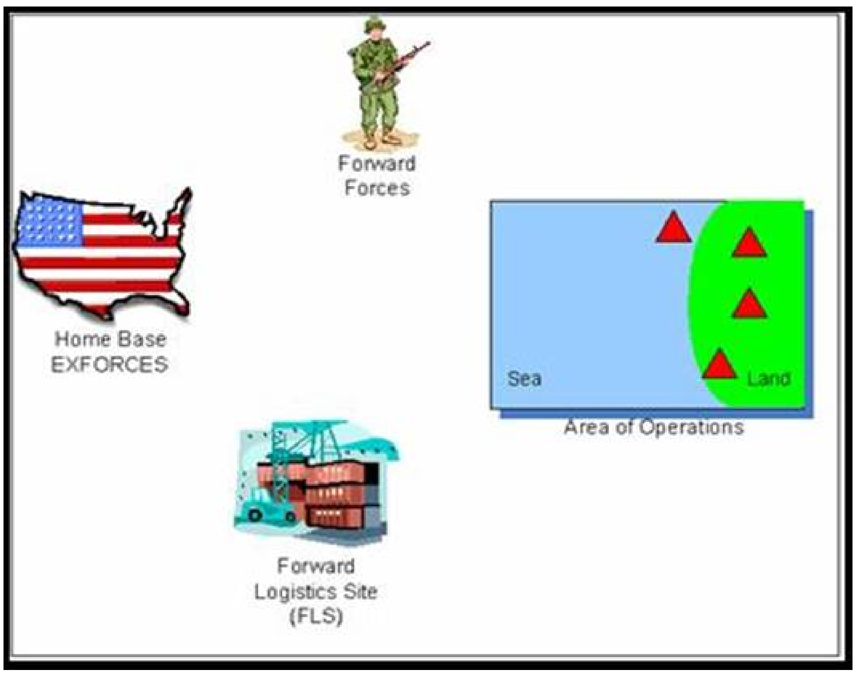

Figure 2-3: Pre-Deployment.

[36] Sea Basing CONOPS, pp. 1-3.
[37] May be en route to the AO on any of the Connectors.

2.3.1 Space

The Area of Operations (AO) may include limited[38] land-based Forward Logistics Sites (FLSs)[39] which support the EXFORCES. These FLSs are as far as 2,000[40] NM from the AO (actual transit distances may be longer due to geography).[41] Critical straight-line air routes are not available and plans are based on flight through international airspace.[42] The littoral region of the AO may include regions that are both favorable and unfavorable[43] to amphibious landings.

2.3.2 Force

EXFORCES are those that…

> "…are rapidly deployable, employable and sustainable throughout the global battlespace regardless of antiaccess, or area-denial environments and independent of existing infrastructure. Designated elements based in the United States, abroad or forward deployed [are] configured for immediate employment and sustained operations in austere environments. These forces [are] capable of seamlessly transitioning to sustained operations as a crisis or conflict develops."[44]

Dependent on the nature of the conflict, the EXFORCE will either accomplish limited operational objectives itself, or prepare the battlespace for follow-on forces and sustained operations. Where it adds cost-effective combat power, the Joint Expeditionary Forces (JEFs) use common expeditionary equipment.[45]

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[38] The requirement for expeditionary forces is driven, in part, by an antiaccess environment. As such, it is reasonable to assume that the number available will not be in the ideal location nor have every desired capability.

[39] Schrady, David, Professor, "Joint Sea Basing Logistics: Analysis Roadmap," unpublished notes, Naval Postgraduate School, Monterey, CA, 30 April 2004.

[40] OPNAV N42 Draft Sea Base Logistical CONOPS, 04 June 2004.

[41] May be the case when a strategic strait is between the FLS and the AO.

[42] The whole Sea Base concept assumes an antiaccess environment. This would be worst case. Additionally, many U.S. strategic lift aircraft do not have Global Airspace Management Technology (United States Air Force Vision 2020).

[43] Examples: mangrove swamps, high-rugged cliffs, barrier reefs/islands, etc.

[44] U.S. Secretary of Defense, Joint Operations Concepts, November 2003.

[45] Certain units may require unique equipment.

The Combined[46] Expeditionary Force is a United States-dominated, joint force augmented by one or more allied partners. This force uses the Component Commander construct as used in the Joint Component Commander organization. JEFs are fully integrated.[47] Specifically, they share common equipment, training, doctrine, and terminology. These forces range in size from a two-man Special Operations Forces (SOF) unit to a Joint Expeditionary Brigade (JEB)-sized force (~14,500 personnel; ~4,800 of which are ground combat troops).[48] Some elements of EXFORCES are forward deployed.[49] EXFORCES and their materiel will be moved, assembled and sustained using multimode vehicles called connectors. EXFORCES and their materiel are transferred between separate connectors and between connectors and geographic objectives by means of transfer systems.

The core competency of the Combined Land Component is sustained, medium and heavy ground combat. The expeditionary elements (EXFOR LAND) of the Combined Land Component include land-focused SOF, light, some medium ground forces, and their support.

The core competency of the Combined Maritime Component is sea power and sealift. The expeditionary elements (EXFOR SEA) of the Combined Maritime Component include Sea Base, expeditionary force protection and expeditionary strike.

The core competency of the Combined Air Component is air power and airlift. The expeditionary elements (EXFOR AIR) of the Combined Air Component include rapid, long-range strike, mobility, and sustainment.

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[46] U.S. Joint Force and another state entity.
[47] Modeled after the SOF and Special Operations Command, Commander Forces.
[48] Approximate JEB size, based on the United States Marine Corps (USMC) Baseline Marine Expeditionary Brigade (MEB) of February 2002 (the 2015 MEB) or the combination of an Army Stryker Brigade and a USMC Marine Expeditionary Unit.
[49] National Military Strategy, 2004, p. 10.

2.3.3 Time

Within ten days of the Deployment Order,[50] the CTF CDR will seize the initiative by putting the preliminary elements[51] of the ground forces at the initial objectives. These objective(s) may be within 240 miles[52] of the Sea Base. The Sea Base may be within 25-100 miles of the coastline.[53] The preliminary elements shall deploy to the initial objective(s) within one period of darkness (10 hrs).[54] These elements are able to either complete the operation or prepare the battlefield for follow-on forces. Expeditionary operations end when the operation's objectives are met or when the strategic environment warrants for the combined force to shift to traditional follow-on support. The EXFORCES will then withdraw, reconstitute, and redeploy. Some or all portions of the initial expeditionary force may remain behind with the follow-on forces.

2.3.4 Threat

The assumed threat includes any adversary ranging from non-state actors (terrorists, insurgents, etc.) with low technology to a near-peer competitor with one or more comparable or superior defense technologies.[55] In both cases, the potential for highly asymmetric threats is assumed.

2.4 Pre-Deployment Phase Logistics Concepts

Table 2-1 lists the critical logistics concepts needed to enable the Pre-Deployment phase.

[50] Quote by VADM Nathman in the Navy League of the United States, June 2004.
[51] Preliminary elements will vary by situation and objectives within that situation. Table summaries of these elements are provided in Enclosure 1A and 1B of Chapter 5.
[52] Sea Basing CONOPS, p. 14.
[53] Ibid., p. 15.
[54] Marine Corps Combat Development Command (MCCDC), "Expeditionary Maneuver Warfare Capability List," 16 June 2003, p. 21.
[55] National Military Strategy, 2004, p. 2.

Functional Area	Associated Logistics Concepts
Command and Control	• Uses self-forming, rapid, reliable networks • Integrates operational and logistical information flows • Uses synergistic command structures • Ensures operational security through secure networks • Is unaffected by environmental conditions • Integrates warriors, sensors, networks, platforms, and weapons over a range of distances • Provides disposition of forces information where needed in a timely manner • Scales to operation
Inventory and Storage	• Scales to operation • Incorporates diverse and adaptable materiel handling systems • Minimizes the number of materiel relocations and handling before reaching ultimate destination(s) • Protects cargo from environmental damage • Protects cargo from motion damage • Restock/resupply of forces does not impact operations • Manages inventory to achieve consistent visibility and tracking from the strategic to the operational • Utilizes adaptive stowage systems for ease of selective offloading and flexibility of materiel handling • Standardizes joint packaging for shipping, handling, and storage • Enhances survivability so that Stow and Breakout operations do not impede operational capabilities • Provides for Intermediate Maintenance capabilities • Automates movement of supplies onboard individual Sea Base platforms
Connectors	• Reach around the globe • Scale to conflict level • Berth and sustain crew and troops • Interface with the Forward Logistics Site(s) • Transfer materiel and personnel (onload/offload) while underway • Survive expected threats • Integrate with the Expeditionary Force Protection • Defend themselves commensurate with their role (transport/Sea Base) • View sufficient Common Operational Picture (COP) elements to meet mission tasking • Support Unmanned Vehicle (UV) operations • Interface among each other and the Sea Base • Carry, deploy, and support Preliminary Elements • Handle medical specific functions (air handling, fluid handling, x-ray, O_2) • Berth wounded personnel • Use modular repair facilities that are equipment- /parts-oriented • Maintain mobility against expected combat damage • Augment Underway Replenishment (UNREP)/Vertical Replenishment (VERTREP)/Connected Replenishment capabilities • Enable assembly of personnel and materiel • Reconfigure to meet mission requirements • Scale in capacity, speed, range, and interoperability • Balance between onload/offload speed and platform stability/maneuvering • Maintain capacity, speed, range, and interoperability so that weather effects don’t adversely impact operational tempo

	• Have sufficient throughput to meet logistical needs • Maintains sufficient availability to complete mission
Transfers	• Move all types of personnel and materiel (Class I-X—see definition/examples in Glossary, water, and MISC) between all types of connectors (large, small, surface, air) • Move personnel and materiel between connectors in sea states 0-5 and in sustained winds of up to 20 kts • Move materiel in all weather conditions (rain, sleet, snow, ice, low visibility) so that operational tempo is not degraded • Ensure equipment materiel condition is durable to withstand long-term exposure to the natural elements • Maintains sufficient availability to complete mission

Table 2-1: Pre-Deployment Associated Logistics Concepts.

2.5 Closure Phase

Once the nation decides to employ military power, the JEB begins closing on the AO. Portions of forces come direct from forward locations, some forces direct from home base and some forces through a Forward Logistics Site (FLS) on their way to the AO. Because of their location and equipment, key elements of these forces arrive ahead of the others.

2.5.1 Intelligence Surveillance and Reconnaissance

As the EXFORCES are closing toward the objective, strategic, operational, and tactical intelligence preparation of the battlespace will begin or intensify. Space, air, sea, land, and cyberspace assets will deploy, gather, fuse, and disseminate intelligence.

2.5.2 Special Operations Force

All Special Operations Forces (SOF) are jointly commanded and controlled and may be comprised of forces from all of the services. SOF perform various missions such as Direct Action, Special Reconnaissance, Psychological Operations, Combat Search and Rescue, etc.[56] These missions occur prior to and/or during the formation of the Sea Base. Prior to the formation of the Sea Base, SOF insertion, support, sustainment, and extraction comes from the continental United States or an FLS. Communications are

[56] Federation of American Scientists, Special Operations Force Reference Manual, Website: http://www.fas.org/irp/agency/dod/socom/sof-ref-2-1, [June 2004].

established between the SOF unit and the CTF CDR; however, once the Sea Base has formed, those units already deployed or any additional SOF required may be supported from the Sea Base.

2.5.3 Expeditionary Force Protection

Expeditionary force protection projects layered organic and external defensive power to protect joint and combined assets and to dissuade and deter possible adversaries during expeditionary operations. Expeditionary force protection defends against the threats described in Section 2.3.4. The Seabased Joint Expeditionary Logistics (JELo) system supports the requirements of Expeditionary Force Protection.

2.5.4 Expeditionary Strike

Expeditionary strike provides offensive lethal and nonlethal effects to shape the battlespace as EXFORCES are closing on the AO, as shown in Figure 2-5. It includes the use of Joint and Combined strike aircraft and cruise missiles, as well as assault forces, information operations, and SOF. The expeditionary logistics systems, including Sea Base, support the requirements of expeditionary strike.

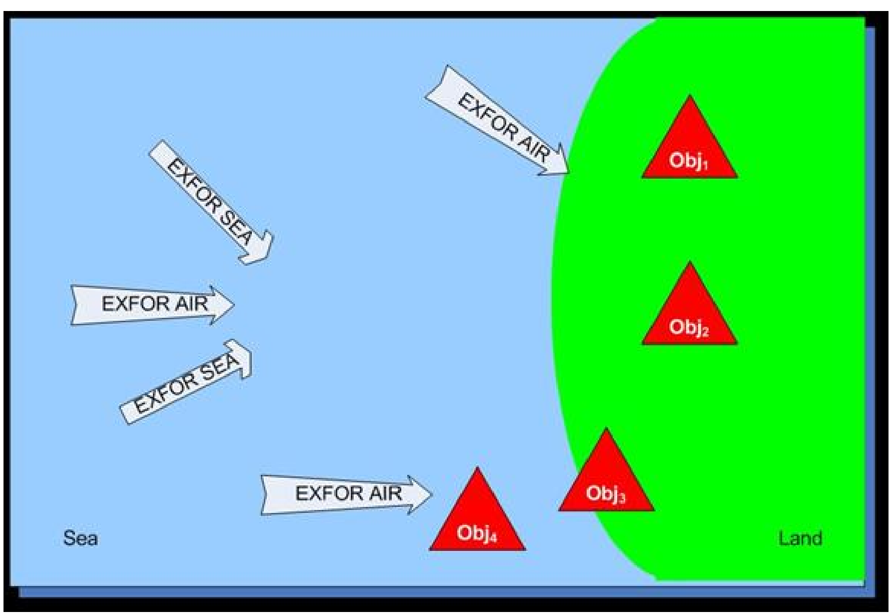

Figure 2-4: Closure (Cont.).

2.5.5 Sea Base Formation

The Sea Base is considered established when there is sufficient Command and Control (C2) and logistical systems in the maritime environment to support expeditionary operations, shown in Figure 2-6. The composition of the Sea Base will vary depending on the requirements and tempo of expeditionary operations.

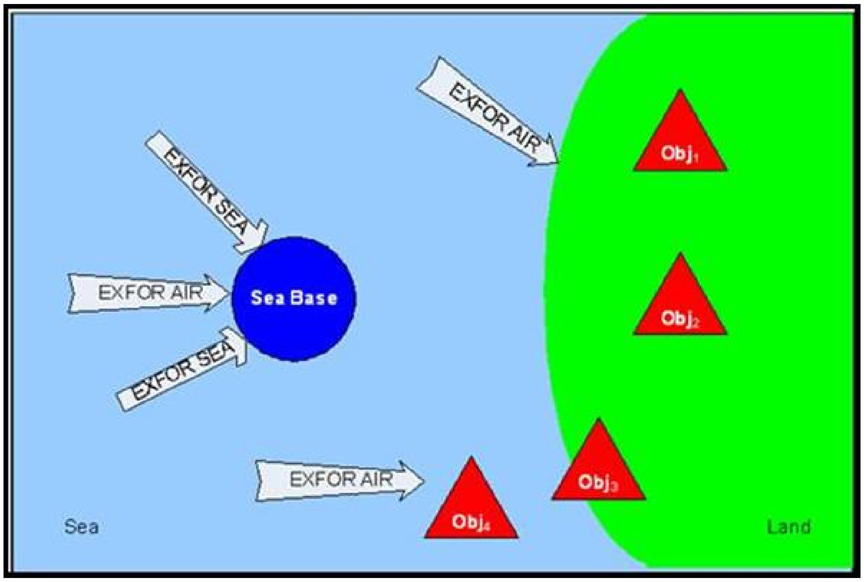

Figure 2-5: Sea Base Formation.

2.6 Employment Phase

Forcible Entry Operations are used in a nonpermissive environment to locate, counter, or penetrate vulnerable seams in an adversary's access denial system to enable the flow of follow-on forces. The essence of Forcible Entry Operations is Ship to Objective Maneuver (STOM), in order to expedite the speed of action relative to the enemy over time. This superior tempo uses the rapid buildup of focused combat power ashore via vertical and surface lift capabilities, tactical/operational flexibility, and maneuver at and from the sea.[57]

[57] Commandant of the U.S. Marine Corps, Ship to Objective Maneuver (STOM), Concept Paper, 25 July 1997.

2.7 Closure and Employment Phase Logistics Concepts

Table 2-2 lists the key logistics concepts needed to support the Closure and Employment Phase.

Functional Area	Associated Logistics Concepts
Command and Control	• Same as Pre-Deployment
Inventory and Storage	• Reduces the time required for assembly of forces and equipment
Connectors	• Have space and modular facilities to support en route and on-station planning • Possess space and facilities to complete final assembly of EXFORCES (forces should be assembled to maximum extent possible prior to onload) • Support SOF equipment and operations • Secure SOF equipment and information • Maintain forward progress sufficient to preserve operational tempo • Resupply in transit up to sea state 5 • Interface among each other and the Sea Base • Launch and recover strike assets • Transport and sustain strike-specific personnel and equipment • Keep position within the Sea Base and within the AO • Keep station automatically at commander's desire • Work with Transfers to move personnel and materiel within the Sea Base • Work with Transfers to move personnel and materiel to and from the Sea Base
Transfers	• Are on-station in the AO in time to enable the formation of the Sea Base and/or expeditionary operations • Are operational within a short time period to enable short-fused movement of materiel and personnel • Are interoperable with connector equipment to enable in-transit supply of materiel • Utilize equipment that is hardened against expected threats • Can decontaminate arriving personnel and materiel • Maintain operability against expected combat damage • Maintain sufficient throughput to complete mission

Table 2-2: Closure Associated Logistics Concepts.

2.8 Sustainment Phase

At some point, a majority of the force is employed at the objective(s) and operations have reached a steady level of effort. Figure 2-7 shows the level of complexity of the logistics lines needed to support this phase.

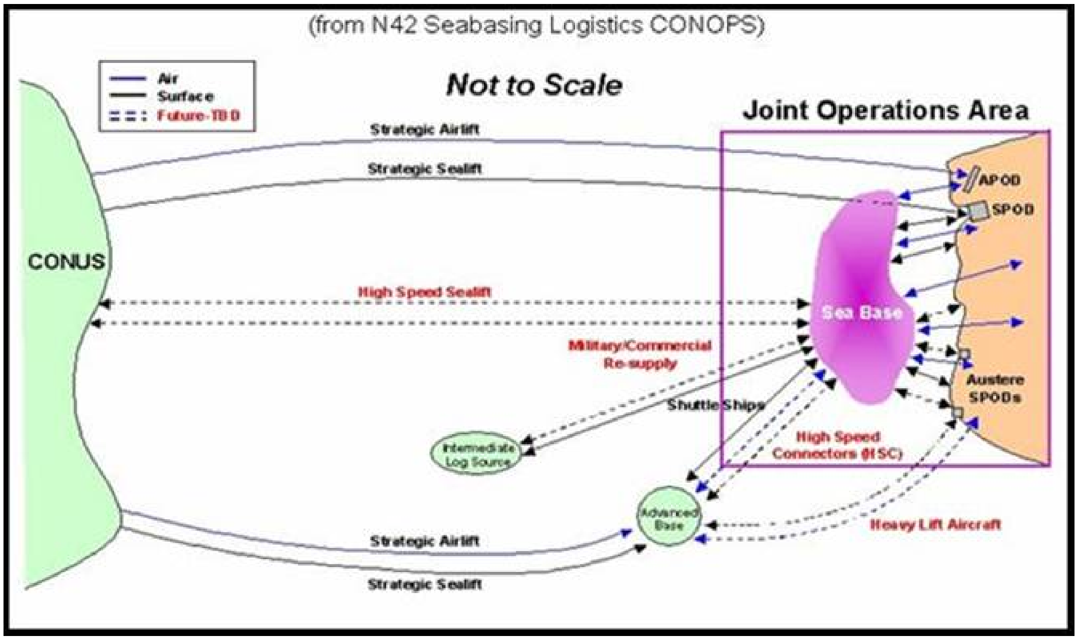

Figure 2-6: Sustainment Operations.

2.8.1 Sustainment Operations Concept

Geographically, objectives may be widely scattered throughout the AO as shown in Figure 2-8.[58] The objectives during Expeditionary Operations generally fall into two categories. The first objectives are those that delay/deter/defeat enemy forces to prevent them massing their own combat power. The second set of objectives enable Follow-on Forces, if necessary. This second set of objectives focuses primarily on logistics enablers: beachheads, ports, airfields, landing zones, etc. Some objectives are time phased and other objectives are simultaneous. Each specific situation determines the order in which the forces engage these objectives, if at all. Only force size constrains the number and sequence of objectives engaged. The logistics system does not impede the number of objectives or the tempo of the operation.

[58] Expeditionary Operations Area/Sea Base Operations Area is that volume that extends out to 240 NM from the Sea Base.

(from N42 Seabasing Logistics CONOPS)

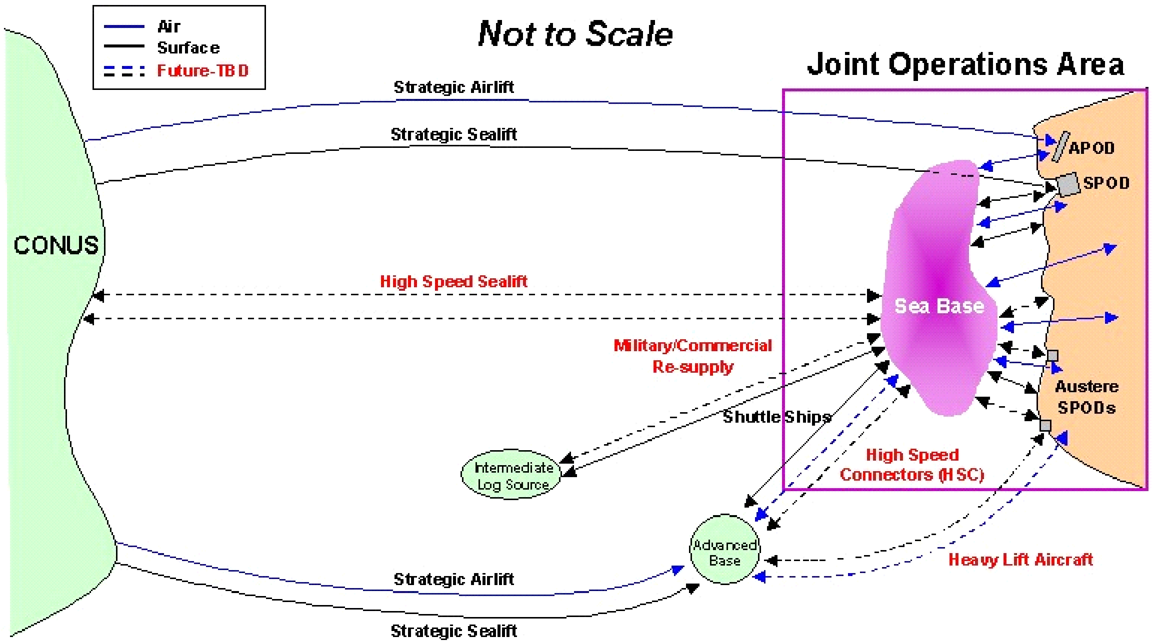

Figure 2-7: Dispersed Objectives.

2.8.2 Sustained Expeditionary Operations

Sustained expeditionary operations (Figure 2-8) are those that last 30 days or longer. During this period, EXFORCES at the objectives receive supplies from the Sea Base at distances up to 200 NM.

2.9 Sustainment Phase Logistics Concepts

Table 2-3 lists the key logistics concepts needed to support the Sustainment Phases.

Functional Area	Associated Logistics Concepts
Command and Control	• Same as Pre-Deployment
Inventory and Storage	• Predicts resupply of EXFORCES • Provides medical support to include rapid movement of medical casualties when required • Permits simultaneous Sea Base and land-based logistics • Allows for a smooth transition from Sea Base logistics to land-based logistics (as ports and/or bases become available) • Ensures adequate decontamination facilities are available for the Sea Base and the EXFORCES
Connectors	• Change configuration to support given mission • Have organic C2 facilities and support modular C2 additions that scale to mission requirements • Decontaminate themselves • Assist in the decontamination of other platforms
Transfers	• Scale to operations • Move personnel and materiel between Connectors at a sufficient throughput so that operational tempo is not degraded • Move standardized containers (cubic size, weight, dimensions) • Move oversized materiel • Move wheeled/motorized vehicles • Move materiel between airborne Connectors and surface Connectors/objective • Move wounded personnel quickly without causing further injury (i.e., low vibration, low acceleration/deceleration forces, protection from the elements)

Table 2-3: Employment and Sustainment Associated Logistics Concepts.

2.10 Reconstitution Phase

Depending on the operation, the EXFORCES either return to the Sea Base or remain engaged and new EXFORCES repopulate the Sea Base. EXFORCES "left behind" reconstitute as part of the sustained operations forces reconstitution[59] effort and redeploy as needed. Seabased EXFORCES reconstitute as the Sea Base is redeploying and/or relocating.

2.10.1 Withdrawal

Once the EXFORCES complete the desired objectives, they start to flow away from the objectives and out of the AO.

[59] Sea Basing CONOPS, p. 28.

2.10.2 Sea Base Reconstitution

Due to equipment failure, combat losses, and/or higher direction, the Sea Base itself may need to be reconstituted. The Sea Base Commander, CTF CDR, and the Regional Combatant Commander combine to restore the Sea Base to the required mission capability.

2.11 Withdrawal and Reconstitution Phase Logistics Concepts

Table 2-4 lists the key logistics concepts needed to support the Withdrawal and Reconstitution Phase.

Functional Area	Associated Logistics Concepts
Command and Control	• Same as Pre-Deployment
Inventory and Storage	• Enables rapid reconstitution of forces • Allows for a smooth transition from Sea Base logistics to land-based logistics (as ports and/or bases become available)
Connectors	• Provide space and facilities for force reconstitution • Provide space and facilities to repackage returning forces • Resupply, reload, and reconfigure the Sea Base platforms • Maneuver to orderly disband the force
Transfers	• Are reliable, maintainable, available and supportable so as not to impact the operational tempo • Move personnel and materiel day or night • Move personnel and materiel between connectors within the Sea Base

Table 2-4: Withdrawal and Reconstitution Associated Logistics Concepts.

2.12 Sea Base Dissolution

At the conclusion of expeditionary operations and when ordered, the components of the Sea Base will detach and proceed on duties assigned. The Sea Base is formally dissolved when C2 and logistics systems support for current expeditionary operations are no longer required.

2.13 Command and Control

The CTF CDR has superior situational awareness of the AO. This situational awareness includes near-real time visibility on logistics information that prevents logistics from impeding operations. This logistics information is contained in the Common Logistics Picture, a subset of the Common Operational Picture. The CTF CDR

sets transport cargo priorities based on the nature of the operations. His designated representative manages the real-time transport operations.

The CTF CDR designates a Sea Base Commander. The Sea Base Commander is in charge of coordinating Sea Base components to support the operations.[60] While the CTF CDR may not actually be in the Sea Base, the Sea Base Commander is embarked on the Sea Base. "[The] CTF Commander needs must drive the logistics process. He should have an in-theater Regional Logistics Commanding Officer to manage all common support/services in theater (peacetime training and war). The Regional Logistics Commanding Officer reports directly to the CTF Commander."[61]

2.14 Medical Operations

The EXFORCE has organic medical capability to treat personnel and the capacity to move their force to dedicated medical facilities (afloat or ashore).[62] Medical evacuation priorities for the connectors are set locally based on triage information from the objectives. Critically injured personnel receive advanced care within 1 hr of injury.[63] EXFORCE medical capability also supports the post-expeditionary operations as required.

2.15 Maintenance and Repair

Engaged EXFORCES will have only limited repair capability and resources organic in the field. However, to maintain speed of maneuver, disabled equipment may be replaced vice repaired. At the appropriate time during operations, a more capable repair team can be deployed to the disabled equipment. To mitigate this need, expeditionary equipment is highly reliable and easily repairable. FLSs and the

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[60] The role of the Sea Base Commander is similar to a current U.S. Naval Base Commanding Officer (CO). Specifically, the Naval Base CO coordinates all of the base's functions to best support tenant commands and forces.
[61] Defense Science Board 1998 study on Department of Defense (DoD) Logistics Transformation, Vol. II.
[62] Marine Corps Requirements Oversight Council Executive Summary: Maritime Prepositioning Force (Future) Capabilities Update and Center for Naval Analysis, Analysis of Alternatives In Progress Review Update #3, 17 September 2003, p. 15.
[63] For certain critical cases (severe burns, internal bleeding, etc.), probability of survival increases dramatically if advanced trauma care can be administered within 1 hr. ["Golden Hour" from Website www.wikipedia.org, June 2004].

Sea Base have limited on-board maintenance and repair. Sea Base maintenance and repair capability is primarily for connectors, specifically for the hard to resupply, hard to remove-and-replace equipment. The Sea Base can also maintain and repair critical embarked equipment.

2.16 Survivability

Survivability ensures the functional effectiveness of the expeditionary force that is degraded by damage. Survivability encompasses both susceptibility and vulnerability. Logistic forces, platforms, sites, transportation modes, lines of communication, and bases are all high-value targets. Ships, aircraft and bases are vulnerable to direct attack by enemy forces or terrorists.[64] All connectors whose mission is to transport expeditionary troops and materiel into a hostile environment and maintain station provide self-protection for personnel from expected hostile threats. Connectors whose primary mission is to shuttle expeditionary personnel and materiel between a non-hostile logistics hub and the AO provide defense and protection against asymmetrical terrorist threats. Connectors whose mission is to shuttle personnel and equipment within the AO to the objective protect themselves and their personnel from expected threats.

2.17 Decontamination

Should the expeditionary forces receive nuclear, biological, or chemical contamination at the objectives, the contaminated equipment will be decontaminated prior to returning to the Sea Base.[65] The Sea Base components have organic decontamination for their own equipment.

2.18 Summary

This Operating Concepts sets the stage for follow-on analysis through the Functional Area Analysis (FAA). Operational phases of Closure, Employment, and Sustainment require detailed definition regarding both process and conditions under which the EXFORCE will operate.

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[64] Marine Corps Warfare Publication 3.21.2, *Aviation Logistics*, p. 4015.
[65] This precludes contaminating the Connectors.

3. FUNCTIONAL AREA ANALYSIS

3.1 Overview

The Functional Area Analysis (FAA) identifies the operational tasks, conditions, and standards that collectively form the requirements needed to achieve the military objectives involved in Seabasing and Joint Expeditionary Logistics (JELo). To identify these requirements, SEA-6 uses the Universal Joint Task List (UJTL) and the Operating Concept (OPSCON) in Chapter 2 of this report. The UJTL is a guide to, "…provide a standardized tool for describing requirements for planning, conducting, evaluating and assessing joint and multinational training."[66] The UJTL is organized according to the three levels of war and includes joint/interoperability tactical tasks and the applicable Service tasks as follows:

- Strategic level - National military tasks
- Strategic level - Theater tasks
- Operational level tasks
- Tactical level tasks

The requirements identified in the FAA are inputs to the Functional Needs Analysis (FNA) phase to assist in the identification of capability gaps or shortcomings that require solutions. Additionally, the information in the FAA is furnished to the Naval Postgraduate School Total Ship Systems Engineering (TSSE) curriculum for their collaborative design effort of a high-speed assault connector.

3.2 Tasks and Conditions

Seabasing and JELo require that unique tasks be accomplished under a variety of conditions. Figure 3-1 illustrates the link between high-level UJTL tasks across the three levels of warfare (strategic, operational, and tactical). The SEA-6 functional teams identify these high-level tasks that enable Seabasing operations. Table 3-1 shows the link between the high-level UJTL tasks and the Seabased JELo operational phases (as described in the OPSCON) that are within scope of the SEA-6 analysis.

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[66] Chairman of the Joint Chiefs of Staff (CJCS), CJCSM 3500.04C, Universal Joint Task List Version 4.2, p. 1.

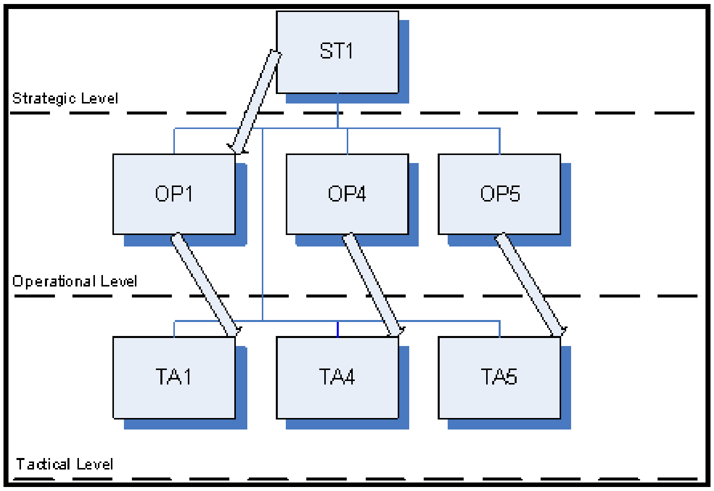

Figure 3-1: UJTL Task Linkage with Levels of Warfare.

OPERATIONAL PHASE	TASK	DESCRIPTION
Closure Phase	ST 1	Deploy, Concentrate and Maneuver Theater Forces
	OP 1	Conduct Operational Movement and Maneuver
Employment Phase	TA 1	Deploy/Conduct Maneuver
Sustainment Phase	OP 4	Provide Operational Logistics and Personnel Support
	OP 5	Provide Operational Command and Control (C2)
	TA 4	Perform Logistics and Combat Service Support
	TA 5	Exercise Command and Control

Table 3-1: Seabased JELo Operational Phases and Associated UJTL Tasks.

Operational conditions are the variables of an operational environment or situation in which a unit, system, or individual is expected to operate that may affect performance.[67] Conditions are organized by three broad categories: physical, military, and civil. The conditions applied to the Closure, Employment, and Sustainment Phases of Joint Expeditionary Operations (JEO) are listed in Figure 3-2. This study does not address and civil environment conditions.

[67] Chairman of the Joint Chiefs of Staff (CJCS) Manual 3500.04C, 01 July 2002, Universal Joint Task List Version 4.2, Glossary, Definitions, p. 1.

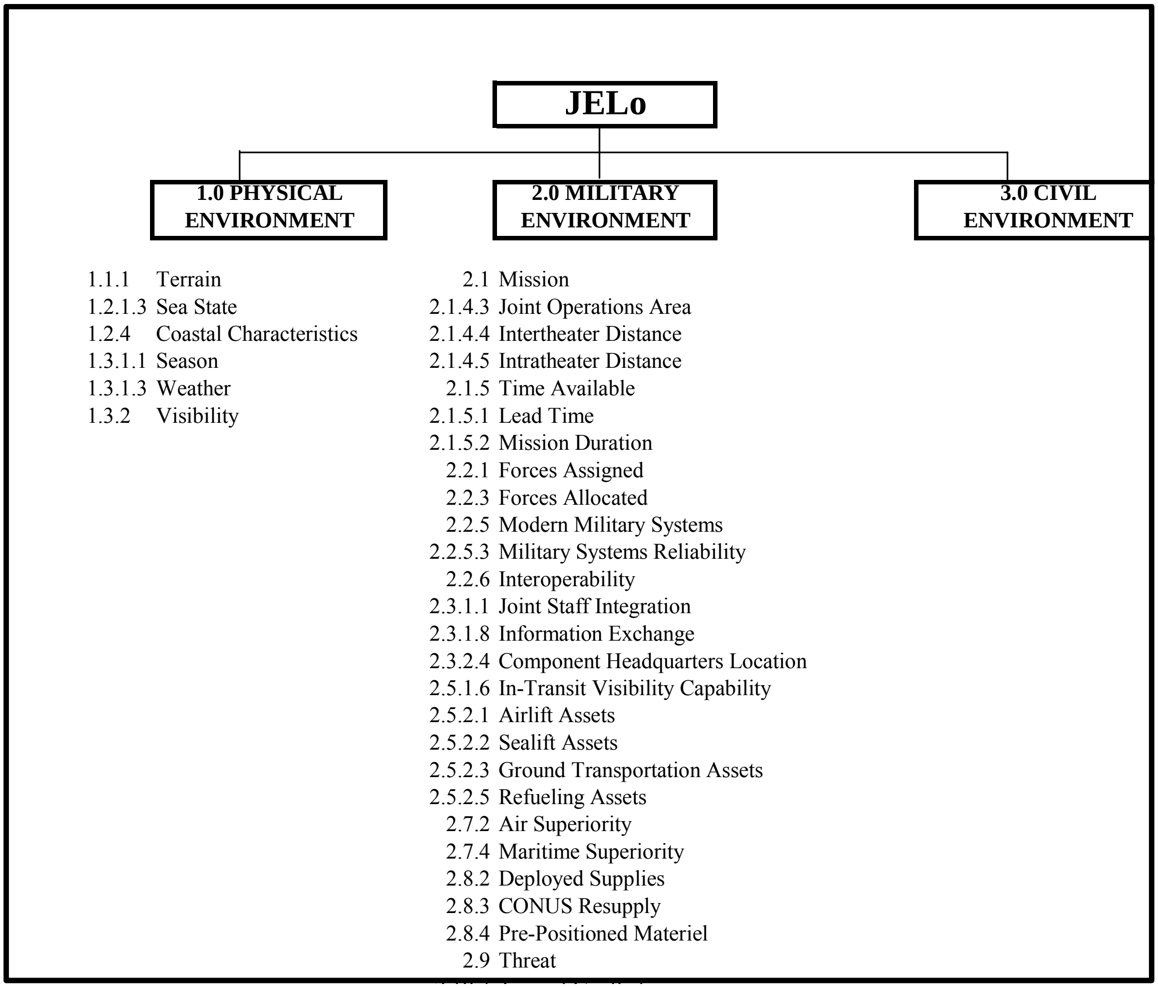

Figure 3-2: UJTL Conditions.

Each task in Table 3-1 must be performed under a variety of conditions depending on the phase of operations. Conditions are expressed within the framework of the phrase, "Perform this task under conditions of…."[68] This phrase is useful when reading the tables of tasks and conditions associated with each operational phase in the following discussion.

[68] Ibid., Enclosure 3, p. C-2.

3.3 Operational Standards

Standards provide a way to express the level of proficiency required to accomplish the desired tasks under the stated conditions.[69] The standards give the Combatant Commander a training guideline when evaluating the readiness of the force to accomplish the required mission.

3.4 Closure Phase

The Operating Concept [Chapter 2] states that once military force is required, a Joint Expeditionary Brigade (JEB) begins closing on the Joint Operations Area (JOA) to seize the initiative within 10 days. Forces may travel direct from forward locations, home base, or through a Forward Logistics Site (FLS). Figure 3-3 shows the current locations of some U.S. military FLSs, which include Guam, Diego Garcia, Sigonella, and Rota. Each FLS is depicted at the center of a 2,000 NM range ring. The closure phase consists of force deployment, transit, and assembly.

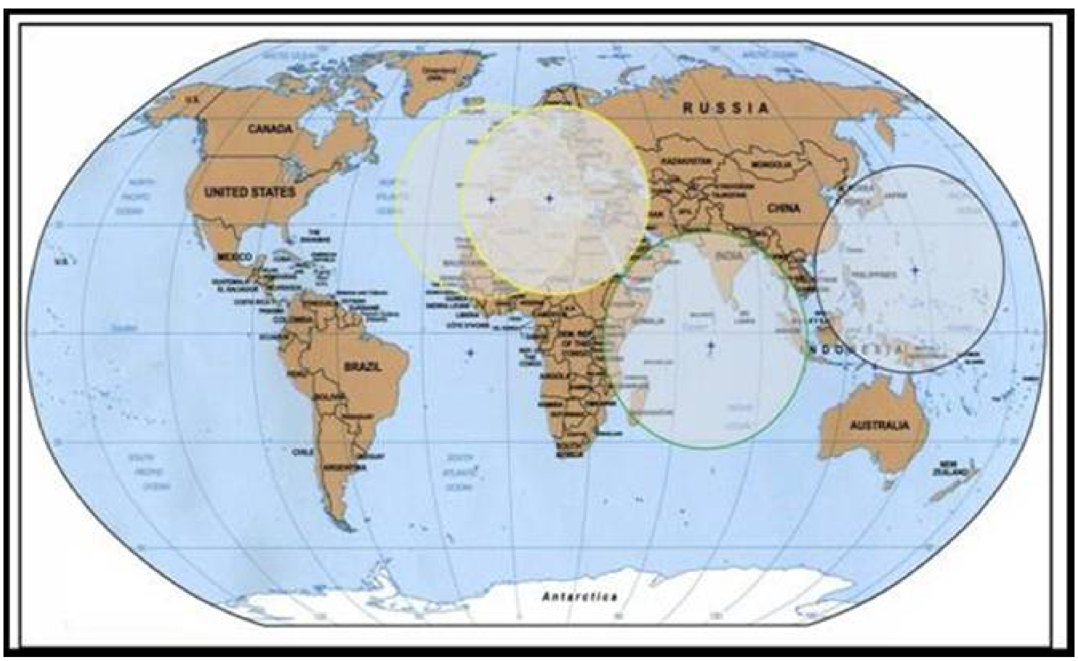

Figure 3-3: Positions of Current Forward Logistics Sites with 2,000 NM Range Rings.[70]

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[69] Chairman of the Joint Chiefs of Staff (CJCS), CJCSM 3500.04C, 01 July 2002, Universal Joint Task List Version 4.2, Appendix B to Enclosure B, p. B-B-1.
[70] Naval Research Advisory Committee (NRAC), Sea Base CONOPS Brief, April 2004.

3.4.1 Deployment and Transit

The UJTL contains subtasks that further define the high-level tasks under ST-1 and OP-1 regarding deployment and transit to the JOA. Table 3-2 shows this subtask breakdown.

		CLOSURE PHASE
TASK	**SUBTASK**	**DESCRIPTION**
ST-1		**Deploy, Concentrate, and Maneuver Theater Forces**
	ST-1.1	Conduct intratheater strategic deployment
	ST-1.1.2.3	Provide onward movement in the theater
	ST-1.1.3	Conduct intratheater deployment of forces
	ST-1.3	Conduct theater strategic maneuver and force positioning
OP-1		**Conduct Operational Movement and Maneuver**
	OP-1.1	Conduct operational movement
	OP-1.1.2	Conduct intratheater deployment and redeployment of forces within the joint operations area (JOA)
	OP-1.1.2.1	Conduct airlift in the joint operations area (JOA)
	OP-1.2	Conduct operational maneuver and force positioning
	OP-1.3	Provide operational mobility

Table 3-2: Deployment and Transit Subtasks.

3.4.2 Assembly

The UJTL contains subtasks that further define the high-level tasks under ST-1 and OP-1 regarding assembly of the JEB. Table 3-3 shows this subtask breakdown. Figure 3-4 shows a generic timeline needed to seize the initiative within 10 days.

		CLOSURE PHASE
TASK	**SUBTASK**	**DESCRIPTION**
ST-1		**Deploy, Concentrate, and Maneuver Theater Forces**
	ST-1.2	Assemble forces
OP-1		**Conduct Operational Movement and Maneuver**
	OP-1.1.3	Conduct joint reception, staging, onward movement, and integration (JRSOI) in the joint operations area (JOA)
	OP-1.2.3	Assemble forces in the joint operations area (JOA)

Table 3-3: Assembly Subtasks.

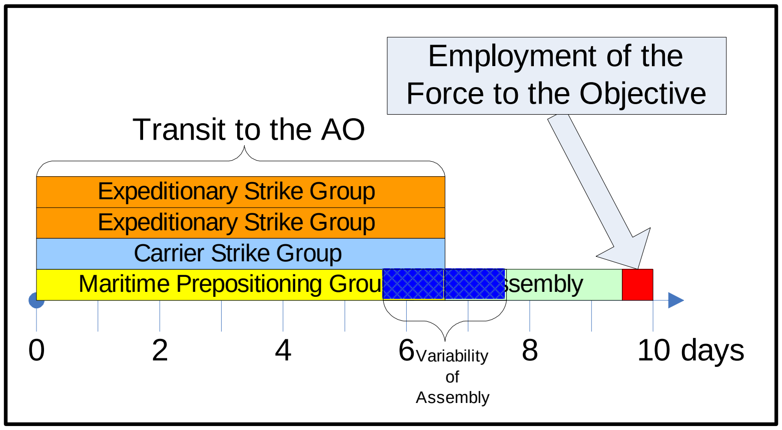

Figure 3-4: Timeline for Force Closure.

The high-level UJTL tasks associated with the closure phase are ST-1 and OP-1. Table 3-4 summarizes the tasks, associated conditions, and JELo requirements for the Closure Phase as defined by SEA-6.

TASK	DESCRIPTION	UJTL CONDITIONS		JELo Requirement
ST 1	Deploy, Concentrate and Maneuver Theater Forces	1.2.1.3	Sea State: Moderate (Beaufort Force 5, Sea State 4, seas 4-8 ft)	Same
		1.3.1.1	Season: Winter, Spring, Summer, Fall	Same
		1.3.1.3	Weather: Clear, Partly Cloudy, Overcast, Precipitating, Stormy	Same
		1.3.2	Visibility: Low (1/8 to 1 nm)	Same
		2.1.4.3	Joint Operations Area: Small (100,000 to 300,000 km^2)	Approx. 230,000 km^2
		2.1.4.4	Intertheater Distance: Short (1,000 to 3,500 nm)	2,000 nm
		2.1.4.5	Intratheater Distance: Moderate (50 to 150 nm) to Long (150 to 500 nm)	240 nm
		2.1.5	Time Available: Short to Moderate	6 days
		2.1.5.1	Lead Time: Short to Moderate	4 days
		2.1.5.2	Mission Duration: Very Short	6 days
		2.2.1	Forces Assigned: Strong (Planned forces in place)	JEB
		2.2.5.3	Military Systems Reliability: Acceptable (Operates at or near established reliability standards maintainable in theater)	Various
		2.2.6	Interoperability: High (Systems, units, or forces can be integrated vertically and horizontally with few work-arounds)	Same
		2.3.1.1	Joint Staff Integration: Full (broadly based and fully interactive)	Logistcis
		2.3.2.4	Component Headquarters Location: Co-location of some	Sea Base/Ashore
		2.5.2.1	Airlift Assets: Limited Availability (somewhat less than planned)	USAF AMC assets
		2.5.2.2	Sealift Assets: Robust Availability (as planned)	USN/MSC assets
		2.5.2.5	Refueling Assets: Limited Availability (somewhat less than planned)	USAF assets
		2.8.4	Pre-Positioned Materiel: Extensive (can equip most ground forces and provide fuel and ammunition for air and naval forces apportioned)	MSC/FLS
OP 1	Conduct Operational Movement and Maneuver	1.2.1.3	Sea State: Moderate (Beaufort Force 5, Sea State 4, seas 4-8 ft)	Same
		1.3.1.1	Season: Winter, Spring, Summer, Fall	Same
		1.3.1.3	Weather: Clear, Partly Cloudy, Overcast, Precipitating, Stormy)	Same
		1.3.2	Visibility: Low (1/8 to 1 nm)	Same
		2.1.4.3	Joint Operations Area: Small (100,000 to 300,000 km^2)	Approx. 230,000 km^2
		2.1.4.4	Intertheater Distance: Short (1,000 to 3,500 nm)	2,000 nm
		2.1.4.5	Intratheater Distance: Moderate (50 to 150 nm) to Long (150 to 500 nm)	240 nm
		2.1.5	Time Available: Short to Moderate	6 days
		2.1.5.1	Lead Time: Short to Moderate	4 days
		2.1.5.2	Mission Duration: Very Short (less than or equal to 30 days)	6 days
		2.2.1	Forces Assigned: Strong (Planned forces in place)	JEB
		2.2.5.3	Military Systems Reliability: Acceptable (Operates at or near established reliability standards maintainable in theater)	Various
		2.2.6	Interoperability: High (Systems, units, or forces can be integrated vertically and horizontally with few work-arounds)	Same
		2.3.1.1	Joint Staff Integration: Full (broadly based and fully interactive)	Logistcis
		2.7.2	Air Superiority: General	CSG/AEF
		2.7.4	Maritime Superiority: Full	CSG/ESG
		2.8.2	Deployed Supplies (Sea Base): Limited (10 to 30 days)	20 to 30 days

Table 3-4: JELo Closure Phase Tasks, Conditions, and Requirements.

3.5 Employment Phase

The SEA-6 OPSCON [Chapter 2] specifies that the JEB be employed at the objective within one period of darkness (POD). For this analysis, one period of darkness is defined as 10 hrs.[71] The Employment Phase consists of task TA-1. Table 3-5 lists the subtasks under TA-1. Table 3-6 summarizes the task, associated conditions, and JELo requirements for the Employment Phase as defined by SEA-6.

[71] Expeditionary Maneuver Warfare List, 16 June 2003, p. 21.

		EMPLOYMENT PHASE
TASK	**SUBTASK**	**DESCRIPTION**
TA-1		**Deploy/Conduct Maneuver**
	TA-1.1.1	Conduct tactical airlift
	TA-1.1.4	Conduct sea and air deployment operations
	TA-1.2.3	Conduct amphibious assault and raid operations

Table 3-5: Employment Subtasks.

TASK	DESCRIPTION	UJTL CONDITIONS		JELo Requirement
TA 1	Deploy/Conduct Maneuver	1.1.1	Terrain: Mountainous, Piedmont, Steppe, Delta, Desert, Jungle	Same
		1.2.1.3	Sea State: Moderate (Beaufort Force 5, Sea State 4, seas 4-8 ft)	Same
		1.2.4	Coastal Characteristics: Moderate (moderate grades, currents some obstacles)	Beachable
		1.3.1.1	Season: Winter, Spring, Summer, Fall	Same
		1.3.1.3	Weather: Clear, Partly Cloudy, Overcast, Precipitating, Stormy)	Same
		1.3.2	Visibility: Low (1/8 to 1 nm)	Same
		2.1.4.5	Intratheater Distance: Moderate (50 to 150 nm) to Long (150 to 500 nm)	240 nm
		2.1.5.2	Mission Duration: Very Short (less than 30 days)	10 hours
		2.2.1	Forces Assigned: Strong (Planned forces in place)	JEB
		2.2.5.3	Military Systems Reliability: Acceptable (Operates at or near established reliability standards maintainable in theater)	Various
		2.3.2.4	Component Headquarters Location: Co-location of some	Sea Base/Ashore
		2.5.1.6	In-Transit Visibility Capability: Full (forces and materiel all use automated identification technologies (AIT) compatible with feeder systems)	Same
		2.8.2	Deployed Supplies (Ashore): Negligible (less than 3 days)	2 to 3 days
		2.9.2	Threat Form: Conventional, Unconventional, Chemical, Biological, Terrorist, Information Warfare	Same

Table 3-6: JELo Employment Phase Tasks, Conditions, and Requirements.

3.6 Sustainment Phase

There are two primary components of sustainment identified in the SEA-6 OPSCON [Chapter 2]: sustainment of forces ashore and sustainment of the Sea Base. This logistical sustainment includes provisions, ammunition, personnel, equipment, fuel, and other support. The SEA-6 OPSCON states that both the Sea Base and the components ashore be sustained for a minimum period of 30 days. The Sustainment Phase consists of tasks OP-4 and OP-5, as well as TA-4 and TA-5. Table 3-7 shows the subtasks for the Sustainment Phase. Table 3-7 summarizes the tasks, associated conditions, and JELo requirements for the Sustainment Phase.

		SUSTAINMENT PHASE
TASK	**SUBTASK**	**DESCRIPTION**
OP-4		**Provide Operational Logistics and Personnel Support**
	4.1	Coordinate supply of arms, munitions, and equipment in the joint operations area (JOA)
	4.2	Synchronize supply of fuel in the JOA
	4.3	Provide for maintenance of equipment in the JOA
	4.4.3.2	Manage flow of casualties in the JOA
OP-5		**Provide Operational Command and Control (C2)**
	5.1.1	Communicate operational information
	5.1.4	Maintain operational information and force status
TA-4		**Perform Logistics and Combat Service Support**
	TA-4.2	Distribute Supplies and Provide Transport Services
	TA-4.4	Conduct Joint Logistics Over-The-Shore Operations (JLOTS)
TA-5		**Exercise C2**
	5.2.1	Establish, operate, and maintain baseline information exchange

Table 3-7: Sustainment Phase Subtasks.

TASK	DESCRIPTION	UJTL CONDITIONS		JELo Requirement
OP 4	Provide Operational Logistics and Personnel Support	1.1.1	Terrain: Mountainous, Piedmont, Steppe, Delta, Desert, Jungle	Same
TA 4	Perform Logistics and Combat Service Support	1.2.1.3	Sea State: Moderate (Beaufort Force 5, Sea State 4, seas 4-8 ft)	Same
		1.2.4	Coastal Characteristics: Moderate (moderate grades, currents some obstacles)	Beachable
		1.3.1.1	Season: Winter, Spring, Summer, Fall	Same
		1.3.1.3	Weather: Clear, Partly Cloudy, Overcast, Precipitating, Stormy)	Same
		1.3.2	Visibility: Low (1/8 to 1 nm)	Same
		2.1.4.3	Joint Operations Area: Small (100,000 to 300,000 km^2)	Approx. 230,000 km^2
		2.1.4.4	Intertheater Distance: Short (1,000 to 3,500 nm)	2,000 nm
		2.1.4.5	Intratheater Distance: Moderate (50 to 150 nm) to Long (150 to 500 nm)	240 nm
		2.1.5	Time Available: Long (weeks to months)	30 days
		2.1.5.1	Lead Time: Moderate (days to weeks)	10 days
		2.1.5.2	Mission Duration: Very Short (less than or equal to 30 days)	30 days
		2.2.1	Forces Assigned: Strong (Planned forces in place)	JEB
		2.2.5.3	Military Systems Reliability: Acceptable (Operates at or near established reliability standards maintainable in theater)	Various
		2.3.1.8	Information Exchange: Unrestricted, Restricted, and Highly Restricted	Same
		2.5.1.6	In-Transit Visibility Capability: Full (forces and materiel all use automated identification technologies (AIT) compatible with feeder systems)	Same
		2.5.2.1	Airlift Assets: Limited (somewhat less than planned)	Various
		2.5.2.2	Sealift Assets: Limited (somewhat less than planned)	Various
		2.5.2.3	Ground Transportation Assets: Limited (somewhat less than planned)	Various
		2.5.2.5	Refueling Assets: Limited (somewhat less than planned)	Various
		2.8.2	Deployed Supplies (Sea Base): Limited (10 to 30 days)	20 to 30 days
		2.8.2	Deployed Supplies (Ashore): Negligible (less than 3 days)	2 to 3 days
		2.8.3	CONUS Resupply: Adequate (no impact on defensive or offensive operations due to lack of long-term logistic support)	Same
		2.9	Threat Form: Conventional, Unconventional, Chemical, Biological, Terrorist, Information Warfare	Same
OP 5	Provide Operational Command and Control (C2)	2.1.5.1	Lead Time: Moderate (days to weeks)	10 days
TA 5	Exercise Command and Control	2.1.5.2	Mission Duration: Very Short (less than or equal to 30 days)	30 days
		2.2.6	Interoperability: High (Systems, units, or forces can be integrated vertically and horizontally with few work-arounds)	Same
		2.3.1.1	Joint Staff Integration: Full (broadly based and fully interactive)	Logistcis
		2.3.1.8	Information Exchange: Unrestricted, Restricted, and Highly Restricted	Same
		2.3.2.4	Component Headquarters Location: Co-location of some	Sea Base/Ashore
		2.5.1.6	In-Transit Visibility Capability: Full (forces and materiel all use automated identification technologies (AIT) compatible with feeder systems)	Same

Table 3-8: JELo Sustainment Phase Tasks, Conditions, and Requirements.

3.7 Summary

These tasks, conditions, and standards further define Seabasing and JELo requirements. Figure 3-3 lists the standards for the high-level UJTL tasks required to accomplish Seabased JELo operations. This foundation feeds into the next project phase where the allocation of these requirements defines the systems and platforms required to provide the desired capabilities.

TASK	DESCRIPTION	STANDARDS
ST 1	Deploy, Concentrate and Maneuver Theater Forces	Complete Closure Phase within 10 Days of Deployment Order
OP 1	Conduct Operational Movement and Maneuver	
TA 1	Deploy/Conduct Maneuver	Complete Employment of 3 Battalion (2-Surface, 1-Vertical) Landing Teams Within One Period of Darkness (10 hours)
OP 4	Provide Operational Logistics and Personnel Support	Sustain the Joint Expeditionary Brigade for 30 Continuous Days of Operation
OP 5	Provide Operational Command and Control (C2)	
TA 4	Perform Logistics and Combat Service Support	
TA 5	Exercise Command and Control	

Figure 3-5: JELo System Standards.

4. DESCRIPTION OF 2004 CAPABILITIES

4.1 Overview

The Functional Area Analysis (FAA), Chapter 3, describes the Joint Expeditionary Logistics (JELo) requirements. As mentioned in the Methodology portion of Chapter 1, the Functional Needs Analysis (FNA) assesses current and programmed capabilities to meet those requirements.[72] Other studies have also assessed current seabasing capability. The purpose of this analysis is to identify and quantify the performance gaps between the capabilities of current (2004) systems and the requirements of the FAA.

To achieve this, a current (2004) equivalent to the Joint Expeditionary Brigade (JEB) is defined, based on the 2015 Marine Expeditionary Brigade (MEB) described in Chapter 5. Once the force is defined, then its seabasing capability is assessed. Once a seabased JEB is defined, its performance against the key requirements of the FAA is assessed. These key requirements are:

- Can the combat maneuver element get boots on the ground within 10 days?
- Can the combat maneuver element deploy to the objective from the Sea Base within one 10-hr period of darkness?
- Can the combat maneuver element be sustained at the objective for 30 days?

Performance against these requirements is assessed in several ways. Previous analytical efforts recorded in the literature are reviewed. The literature review, while extensive, is not exhaustive. Where previous studies do not specifically address performance, or the performance assessment is vague, analysis is performed using simple, deterministic estimates. Closure estimates are performed based on time/speed/distance against the South East Asia scenario (Andaman Sea/Burma)

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[72] CJCSM 3170.01A, “JCIDS Process,” 12 March 2004, p. A-2.

described in Chapter 9. The 2004 systems are not modeled. This analysis is conducted without any formal relationship with the U.S. Marine Corps (USMC). Outside interaction is limited to informal conversations with USMC personnel at the Naval Postgraduate School (NPS) and phone conversations with personnel on the Expeditionary Warfare Training Group Pacific staff.

4.2 Joint Expeditionary Brigade Force

Expeditionary brigades have existed throughout U.S. military history, and exist today. In the last several years, the USMC has returned to the Expeditionary Brigade name and unit organization. The 2nd Marine Expeditionary Brigade Website shows that today's MEB is well defined.[73] Although expeditionary and amphibious, the current MEB is not purpose-built around the Sea Base concept. Arriving at a 2004 equivalent to the future MEB concept described in Chapter 5 requires modifying the current MEB structure and organization. This modification is based on the core unit of a MEB, the Battalion Landing Team (BLT). The current packaging of a BLT is the Marine Expeditionary Unit (MEU).

4.2.1 Marine Expeditionary Unit[74]

The MEU is task-organized to accomplish a broad range of mission requirements. With a total strength of about 2,200 personnel, the MEU is built around a reinforced infantry battalion, a composite aircraft squadron, and a service support group. Specifically, it is made up of a command element (CE); a reinforced infantry battalion as the ground combat element (GCE); a reinforced helicopter squadron as the aviation combat element (ACE); and a combat service support element (CSSE) designated the MEU Service Support Group (MSSG).

The **Command Element (CE)** provides command and control of the three Major Subordinate Elements (MSEs).

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[73] "2nd Marine Expeditionary Brigade," (02 August 2004 [cited 20 November 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/agency/usmc/2meb.htm.
[74] "Marine Expeditionary Unit," (09 June 2003 [cited 20 November 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/agency/usmc/meu.htm.

The **Ground Combat Element (GCE)** of a MEU is a BLT, a reinforced infantry battalion of approximately 1,200 Marines, including three rifle companies. This element normally includes artillery, engineers, light armored infantry, anti-armor, assault amphibian and division reconnaissance units as listed below:

- Artillery battery configured with six 155mm howitzers. The artillery battery includes its own truck platoon with a mix of 1-ton and 5-ton trucks for carrying ammunition and towing artillery pieces.
- Light Armored Reconnaissance (LAR) detachment configured with 16 Light Armored Vehicles (LAV).
- Assault Amphibian Vehicle (AAV) platoon configured with 15 AAVs.
- TOW platoon: provides a heavy anti-armor capability with eight TOW anti-armor missile launchers.
- Tank platoon (when required for a specific operation) configured with four M1A1 main battle tanks.

The **Aviation Combat Element (ACE)** of a MEU is a reinforced, medium-lift helicopter squadron. The reinforcements include a mix of transport helicopters, attack helicopters, a detachment from the Marine Air Control Group (MACG), a Low Altitude Air Defense (LAAD) section and a detachment from the Marine Wing Support Group (MWSG), and VSTOL attack aircraft. Land-based aerial refueling and transport aircraft provide support if within range. A typical ACE includes:

- Marine Medium Helicopter Squadron (HMM), configured with 12 CH-46E helicopters, that provides medium-lift assault support and is the core of the ACE.
- Marine Heavy Helicopter Squadron (HMH) detachment, configured with 4 CH-53E helicopters, that provides extended-range, heavy-lift assault support.
- Marine Light Attack Squadron (HMLA) detachment, configured with 4 AH-1W attack helicopters and 3 UH-1N utility helicopters, that provides close air support, airborne command and control, and escort.

- Marine Attack Squadron (VMA) detachment, configured with 6 AV-8B Harrier aircraft that provide organic close air support (when required for a specific operation; not all MEU deployments include the Harrier). The AV-8B Harrier may be substituted for the attack helicopters. When appropriate shipping (i.e., LHA, LHD) is not available, they are placed on CONUS standby and prepared to deploy within 96 hrs.
- Marine Aerial Refueling/Transport Squadron (VMGR) detachment, configured with 2 KC-130 aircraft: in CONUS or at the forward logistics site, on standby and prepared to deploy within 96 hrs.
- Marine Air Control Group (MACG) detachment that encompasses the LAAD battery detachment that provides low level, close-in air defense.

The **Combat Service Support Element (CSSE)** is formed from less than 300 Marines and sailors. It provides combat service support (i.e., supply, maintenance, transportation, explosive ordnance disposal, military police, disbursing (pay services), water production and distribution, engineering, medical and dental services, fuel storage and distribution) and other services to the deployed MEU.

The MEU is normally embarked aboard three amphibious ships to form a forward-deployed, naval expeditionary force. The unique capability of this force is to quickly employ armored forces, including M1A1 battle tanks and heavy assault vehicles, and logistically support them from the amphibious ships. The Landing Craft Air Cushioned (LCAC) carry the heavy equipment ashore, while Amphibious Assault Vehicles (AAVs) carry the troops ashore. Both launch via the well decks of the amphibious ships. The helicopters bring troops, lighter vehicles, and supplies to the objective.

To sustain themselves, the MEU brings 15 days of supplies in classes I, II, VIII, and IX.[75] The amphibious ships themselves carry 15 days of class III (B), IV, and V

[75] Global Security.org, "Classes and Subclasses of Supply," 29 September 2002, <http://www.globalsecurity.org/military/intro/supclass.htm> (04 November 2004).

aboard; these supplies constitute the Landing Force Operational Readiness Material (LFORM) to support the embarked MEU.

4.2.2 A MEB of MEUs

Troops, vehicles, and assault connectors (surface craft and aircraft) are the major units of combat power in a MEU. A MEB is approximated by aggregating equivalent numbers of these components. The following calculations show the approximation. Table 4-1 shows the side-by-side comparison of key platforms. Figure 4-1 shows a similar comparison.

- 1 JEB SBME = 3 BLT ≈ 4,800 combat troops
  - 1 MEU ≈ 1,200 combat troops
  - MEU ≈ 4,800 combat troops
  - 1 JEB Sea Base Maneuver Element ≈ 4 MEU
- 1 MEU ACE afloat ≈ 30 aircraft
  - MEU ACE afloat ≈ 120 aircraft
  - 1 JEB Sea Based ACE ≈ 120 aircraft ≈ 4 MEU
- 3 BLT ≈ 500 vehicles ≈ 4 MEU
  - 1 MEU ≈ 120 vehicles
  - MEU ≈ 480 vehicles

2004 MEB	**Combat Troops**	**Tanks**	**LAV**	**AAV**	**LCAC**	**CH-46**	**CH-53**	**AV-8B**	**AH-1/UH-1**
Four MEUs	4,800	16	84	60	36	48	16	24	16/12
2015 MEB	**Combat Troops**	**Tanks**	**LAV**	**EFV**	**LCAC**	**MV-22**	**CH-53**	**JSF**	**AH-1/UH-1**
	4,845	20	75	98	24	48	20	36	18/9

Table 4-1: Notional 2004 MEB vs. 2015 MEB.

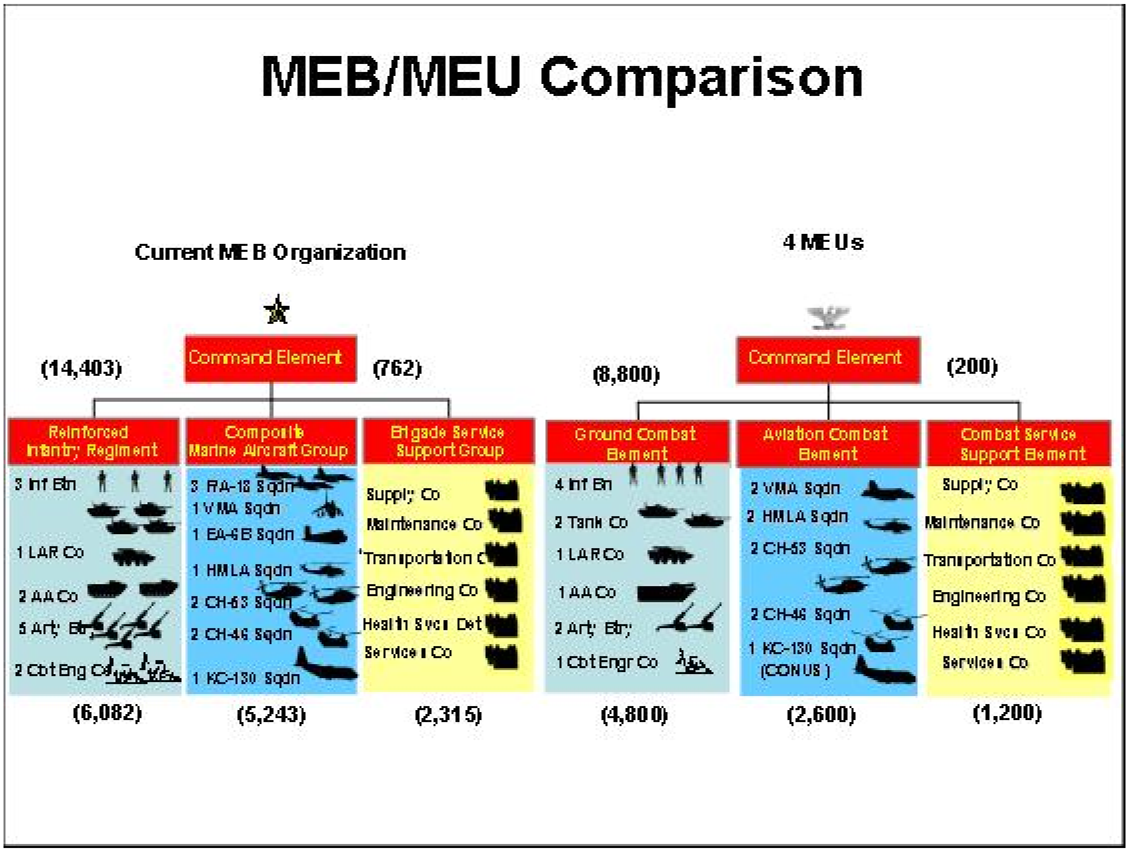

Figure 4-1: MEB/MEU Comparison.

The additional 1,200+ troops listed in the first column of the current MEB organization in Figure 4-1 do not deploy to the objective, making that total approximately 4,800. This estimate shows that 4 MEUs approximate the equivalent numbers of ground combat troops, equipment, and assault connectors as a MEB. Although the four MEUs have significant fighting capability, they do not have equivalent logistical or command and control personnel. The support structure in a MEB is not found within a MEU, even with multiple MEUs combined.

4.3 Expeditionary Strike Group

The current means of deploying a MEU is a U.S. Navy Expeditionary Strike Group (ESG), shown in Figure 4-2. An ESG is built around a mix of amphibious ships (LHA, LPD and LSD)[76] plus an escort force that includes a cruiser, destroyer, frigate and

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[76] "Expeditionary Strike Group" (02 August 2004 [cited 20 November 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/agency/navy/esg.htm.

submarine. These escort ships provide Sea Shield for the ESG, as well as Sea Strike in the form of Tomahawk and gunfire support.

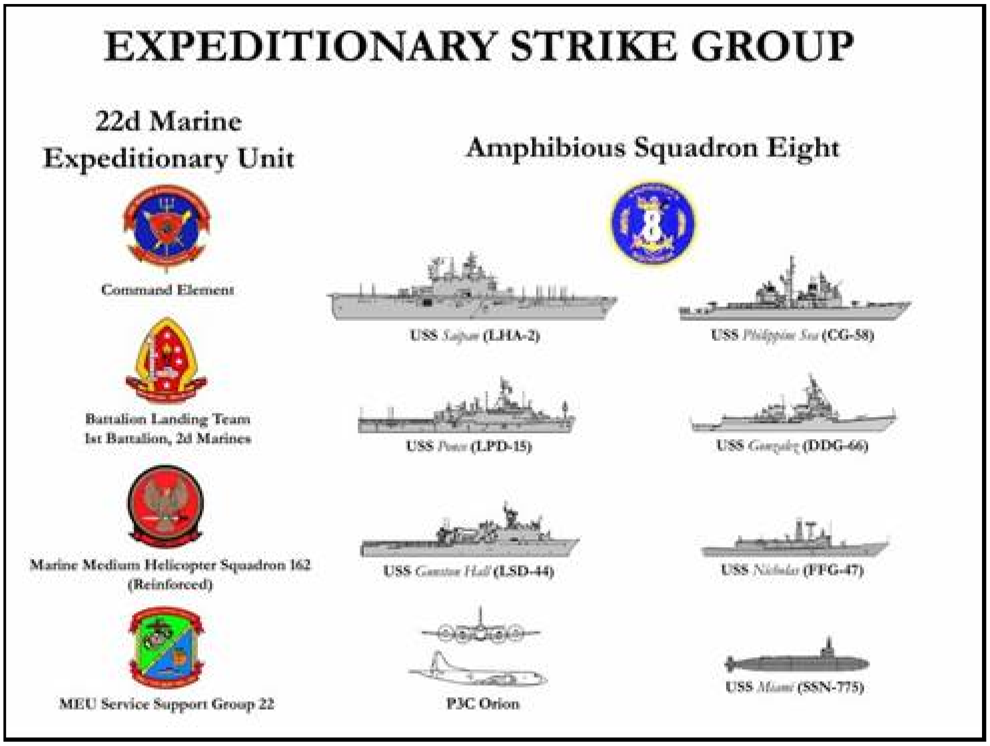

Figure 4-2: Sample ESG.[77]

In general, an ESG deploys with one big-deck amphibious ship and two smaller ones. The big-deck ship will be either a LHA or a LHD. An LHA-1 Tarawa Class can deploy approximately 1,800 Marines, 4 CH-53s, 12 CH-46s, 2 UH-1Ys, 4 AH-1Zs, 6 AV-8Bs, and 4 LCACs via its well deck. If the ESG deploys with a LHD vice an LHA, the LHD-1 Wasp Class can deploy 1,600-1,900 Marines and can carry 4 CH-53s, 12 CH-46s, 4 UH-1Ys, 4 AH-1Zs, and 6 AV-8Bs. Additionally, 3 LCACs and 40 AAVs are deployed from the LHD via its well decks.

The two additional smaller amphibious ships in an ESG are an LPD and LSD. The LPD-4 Austin Class can deploy 800 Marines by receiving and launching CH-46 and CH-53 helicopters and its own LCAC. The last LPD Austin Class is expected to be decommissioned in 2008. The LSD-41 Whidbey Island Class and the LSD-49

[77] "Expeditionary Strike Group," http://www.globalsecurity.org/military/agency/navy/esg.htm.

Harpers Ferry Class can deploy 400 Marines, 2 CH-53s, and 4 LCACs via a well deck. Table 4-2 summarizes the ESG amphibious ships and their embarked MEUs.

	Combat Troops	Tanks	LAV	AAV	LCAC	CH-46	CH-53	AV-8B	AH-1/UH-1
LHA	600	4	8	0	4	12	4	6	4/3
LHD	600	4	8	0	3	12	4	6	4/4
LPD	400	0	0	15	1	0	0	0	0
LSD	200	0	8	0	4	0	0	0	0
Total MEU/ESG	1,200	4	16	15	9	12	4	6	4/3
Four MEU/ESGs	4,800	16	84	60	36	48	16	24	16/12

Table 4-2: Major Platforms of a ESG-based Notional 2004 MEB.

4.4 Closure Phase

As discussed in the JELo Operating Concept, Chapter 2, closure is the process or phase where troops and equipment move to the Sea Base. System performance in the closure phase is highly dependent on the distance and speed the units must travel. Other studies have assessed the closure performance of ESGs. In 1998, the Naval Studies Board report on Naval Expeditionary Logistics[78] said "30 days or more…" In 2000, the OPNAV N7 Draft Sea Basing CONOPS,[79] states "…4-6 weeks…" In 2003, the OPNAV Naval Capabilities Plan[80] states "within 14 days…" Due to the variability in previous studies, one is performed here.

4.4.1 Closure Estimate

Currently, there are 7 MEUs in the USMC. At any given time, 1 is in Okinawa, Japan; 2 are on each coast of the U.S. (Camp Lejeune and Camp Pendleton); and 2 are forward-deployed in ESGs. Figure 4-3 shows a notional distribution of ESGs. Historically, 1 ESG is deployed in the Mediterranean and 1 in the Pacific, including the Persian Gulf and Indian Ocean. The performance estimate below assumes a peacetime deployment schedule that has only 2 MEUs forward-deployed at a time. If the U.S. is

[78] Naval Studies Board, "Naval Expeditionary Logistics," (National Academy Press, Washington, DC, 1998), p. 3-1.
[79] OPNAV N7, "Draft Sea Basing CONOPS," unpublished working papers, 11 March 2004, p. 6.
[80] Cited by Kaskin, Jonathan (OPNAV N42) in "Rapid Strategic Lift Ship Brief," unpublished working papers, slide 5.

engaged in a major operation such as Iraq or Afghanistan, the time to close will be much longer, as they will have to prepare and deploy MEUs during their stand down period.

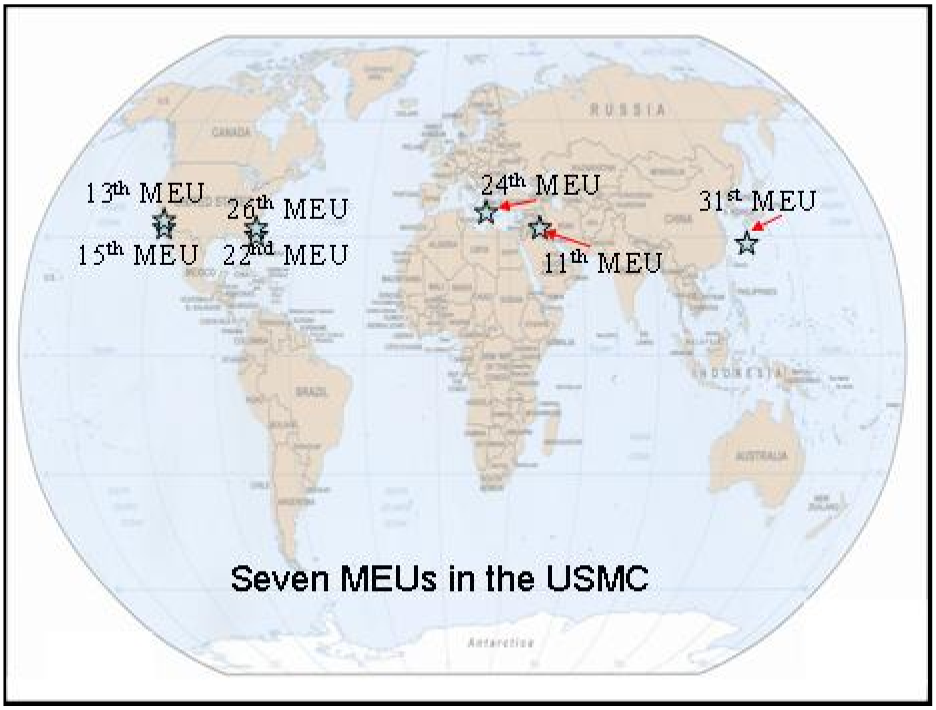

Figure 4-3: Notional MEU Disposition.

Closure performance is estimated using the following assumptions:

- ESG Speed of Advance (SOA) = 15 kts; based on amphibious ship speed limitations.[81]
- A deployed ESG can be headed toward the Area of Operations (AO) within 6 hrs.[82]
- The nondeployed ESGs are at-sea, performing workups and can deploy in 4 days (96 hrs).

[81] LT Ivan Jimenez, LT Bill Partington, and LT John Gainey, interview, written notes, Monterey, CA, 25 November 2004.
[82] 2nd MEB Website: www.globalsecurity.org/military/agency/usmc/2meb.htm.

Enclosure 1 shows the actual routes taken and time calculations from the various points of debarkation for deployed and nondeployed ESGs to the Andaman Sea as stated in the South East Asia Scenario (Burma) in Chapter 9. Table 4-3 summarizes the estimated performance using these assumptions.

START POSITION	END	DISTANCE (NM)	ARRIVAL	CHOKEPOINTS
Persian Gulf	Andaman Sea	~ 3,200	C + 8	Strait of Hormuz
Japan	Andaman Sea	~ 3,500	C + 9	Malacca Strait
Mediterranean	Andaman Sea	~ 5,600	C + 15	Suez Canal/Bab el Mandeb
Camp Pendleton	Andaman Sea	~ 9,300	C + 24	Malacca Strait
Camp Lejeune	Andaman Sea	~ 9,900	C + 27	Suez Canal/Bab el Mandeb

Table 4-3: Time-Speed-Distance Calculations for MEU Arrival.

This estimate shows that an ESG, transiting at 15 kts from the Persian Gulf, could be in the Andaman Sea in approximately 8 days. The second ESG leaves from Japan, expending a day to load the Marines at Okinawa, and arrives at the AO in 9 days. The third, next-closest ESG deploys from the Mediterranean Sea and arrives in approximately 15 days. In 16 days, three-fourths of the JEB is assembled and ready for operations. The last ESG, assumed to be in workups such as Joint Task Force Exercise (JTFEX), sorties from the U.S. This ESG takes an estimated 96 hrs to prepare and deploy. Without considering the time to prepare forces to deploy, approximately 25-30 days of steaming are required to reach the objective area from either coast. With the preparation and transit time, an estimated 30-35 days are required to arrive at the AO, which greatly delays the start of operations. From the time the deployment order is given, it takes at least 30 days to begin an assault with a MEB-sized force supported completely by a Sea Base. Figures 4-4 and 4-5 show a notional force arrival timeline. Only 50% of the force is closed by day 10—a 50% gap. Stated another way, the four ESGs arrive in 28 days; 18 days longer than the required 10 days.

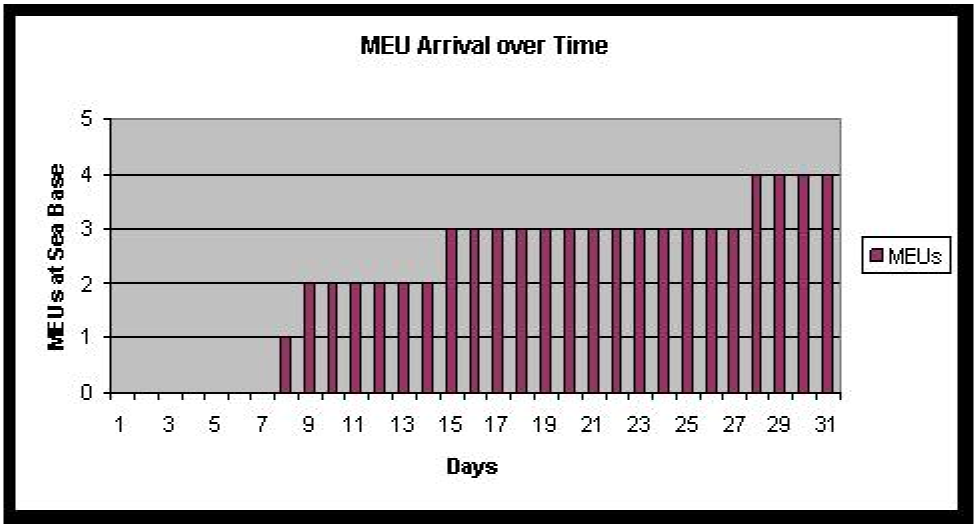

Figure 4-4: MEU Arrival Timeline.

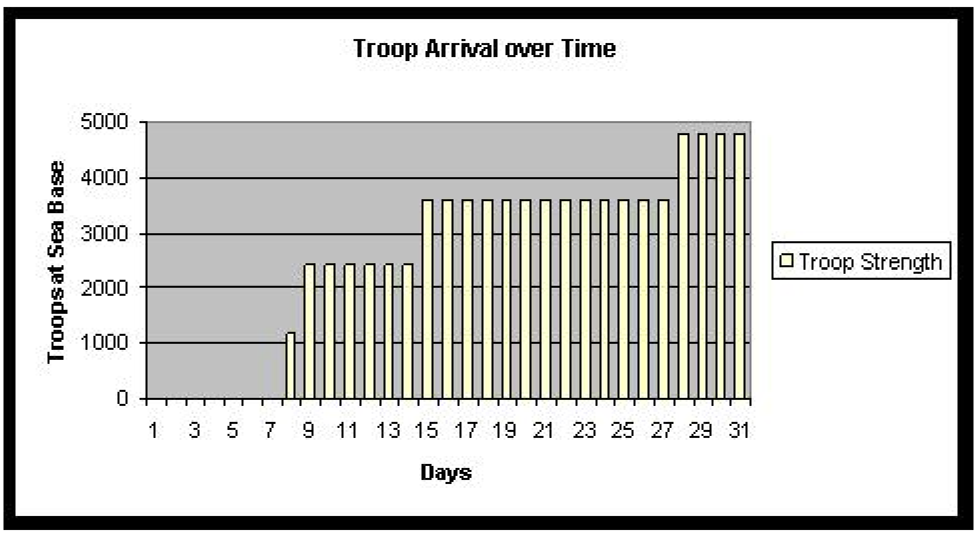

Figure 4-5: Combat Troop Arrival Timeline.

4.5 Employment Phase

Because the ESGs deploy with organic Sea Shield and Sea Strike capability, the ESG can go right to the AO and on to the Sea Base while protecting itself. To employ, the 4-ESG Sea Base closes to 25 NM—the maximum range that assault craft can reach the shore and keep the ship out of any shore-based radar horizon. Landing the BLTs will take approximately 12-24 hrs, but an additional 48-72 hrs is required to land all support

equipment and personnel.[83] This delay for support materiel represents an operational pause for supply and reorganization. This pause loses momentum, which decreases operational tempo.[84] The following quotes from the 1998 Naval Studies Board report on *Naval Expeditionary Logistics* summarize their findings on employment:[85]

> "…air (employment from 85 NM) …took 12 hrs…"
>
> " …25 miles at sea…took 5 days…unacceptably long…"
>
> "To move…ashore in (2 days)… had to close within 4 miles…"

Current MEU employment requires close coordination and effective command and control. A detailed traffic flow plan and real-time coordination via radio is used to ensure proper synchronization and phasing, and to prevent congestion at the beach landing area. For multiple MEUs into the same objective area, additional delay for friction is anticipated. The MAGTF Planner's Reference Guide allows up to 60 minutes per wave for friction.[86]

4.6 Sustainment Phase

The Sea Base concept envisions the troops ashore being resupplied from the ships of the Sea Base. Implicit in this vision is that the ships themselves are resupplied.

4.6.1 ESG Sustainment

Current ESG amphibious ships carry approximately 15 Days of Supply (DOS) of commodity class III, IV, and V for each MEU.[87] If combat operations are expected to exceed 15 days, the ESG must be resupplied. The larger amphibious ships can refuel the escort vessels, but they themselves need resupply. Although all ships in the ESG are

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[83] CWO3 Jerousek III, Albert E, EXPWARTRAGRUPAC [albert.jerousek@navy.mil], "MEU Assault Timeline," 09 November 2004, office communication (11 November, 2004). Major Rosen, Kevin C., EXPWARTRAGRUPAC [kevin.rosen@navy.mil], "MEU Assault Timeline," 09 November 2004, office communication (11 November 2004).
[84] Office of Under Secretary of Defense for Acquisition, Technology, and Logistics. 2003. Defense Science Board Task Force on Sea Basing.
[85] Naval Studies Board, "Naval Expeditionary Logistics," p. 3-3.
[86] USMC, MAGTF Planner's Reference Guide, April 2001, p. 35.
[87] "Marine Expeditionary Unit," (09 June 2003 [cited 20 November 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/agency/usmc/meu.htm.

capable of Underway Replenishment (UNREP), a Combat Logistics Force (CLF) resupply ship is not assigned to the ESG[88]. The CLF supports the Carrier Strike Groups (CSG) and are not loaded with the USMC-specific materiel and ammunition. Resupplying the ESG requires either sending the amphibious ships to a secure forward logistics site and then back, or sending a Maritime Prepositioning Force (MPF) ship, which carries extra equipment and supplies. An MPF ship could arrive in the Andaman Sea from Diego Garcia within four days. However, the MPF ships are commercial-design cargo ships and cannot UNREP; they require a secure, developed port facility or lighterage in sea state two or less, to off load their cargo. If no port facility is available, but a secure airfield is available, heavy airlift assets can provide limited re-supply. Resupply is limited because airlift cannot easily deliver the volume of fuel and ammo required to sustain operations.

This current sustainment capability requires that the initial combat troops secure a port facility and/or an airfield to permit the delivery of the additional troops, equipment, and supplies in a benign environment, free from hostilities.[89] If both of these facilities were available in the objective area, the sustainment functions of the ESG could be moved ashore. While this would lessen the requirement on the ESGs, it would increase the requirements for force protection and the "footprint" ashore. However, a basic premise of the Sea Base concept is to minimize the footprint ashore and keep logistics functions at sea. Therefore, because the Sea Base concept is based on the premise that no port facility or airfield is available, the 15-day limitation on at-sea sustainment is the primary gap in the 2004 capability.

[88] Based on SEA-6 calculations, one T-AOE could resupply all four MEUs in one trip. The required amounts of the four classes of supplies, calculated using Table 4-4 factors multiplied by four MEUs, is expected to be 200 tons of food, 504,000 gallons of water, 863 tons of ammunition, and 76,252 bbls of fuel. A single T-AOE can supply 650 tons of dry stores, 1,800 tons of ammo, and 156,000 bbls of fuel to the ESGs in one trip.

[89] Commission on Physical Sciences, Mathematics, and Applications, National Research Council. 1999. Naval Expeditionary Logistics: "Enabling Operational Maneuver From the Sea." Washington, DC: National Academies Press.

4.6.2 Objective Sustainment

Table 4-4 displays the four primary classes of supplies and the required amount of each per man per day.

Food (Class 1)	Water (Class 1)	Fuel (Class III)		Ammunition (Class V)	
Constant	Constant	Assault Phase	Assault Phase	Sustain Phase	Sustain Phase
5.58 lbs/day/troop	7.00 gal/day/troop	63,842 gal/day	64.21 gal/day/troop	48,145 lbs/day	3.88 lbs/day/troop

Table 4-4: MEU Logistics Planning Factors.[90]

To calculate the amount of supplies required to sustain the troops ashore, the per Marine per day planning factors listed in Table 4-4 are multiplied by the number of troops employed ashore. For the ~ 5,000 troops of the JEB maneuver element, this equates to over 760 short tons of supply (JEB DOS calculation in Chapter 6) that need to be moved every 24 hrs. To the extent possible, the combat troops ashore are resupplied by vertical lift. Vertical sustainment enables direct-to-objective maneuver by reducing reliance on supply lines that are stretched over long distances. Additionally, such logistic convoys are especially vulnerable to enemy attack.

Using the lift capacities and mission radii in the MAGTF Planner's Reference Guide for the CH-46 and CH-53 assets listed in Table 4-1, and an assumed operational availability of 0.7 for both types, a quick estimate based on weight alone shows that they can lift one DOS every 24 hrs from a range of 50 NM.

4.6.3 Medical Evacuation

Either UH-1N or CH-46E aircraft evacuate the wounded. At 100 kts, each helicopter can cover the 25 NM to the beach in 15 minutes flight time each way. Since the UH-1N has a range of only 150 NM,[91] wounded will only be able to reach advanced medical care onboard ship within the "golden hour" when the Sea Base to objective radius is less than approximately 70 NM.

[90] Marine Corps combat Development Command, "MAGTF Planner's Reference Manual," April 2001, (UNITED STATES MARINE CORPS MSTP Center (C 54) MCCDC, Quantico, VA, 20 April 2001), p. 118.
[91] Ibid., p. 24.

4.7 Survivability

The ESG brings its own Sea Shield and a Sea Strike capability. The multiple ESGs and their associated Marine air wing have robust capability, including combat air patrol, suppression of enemy air defenses, conventional strike, and close air support. The addition of a CSG augments these capabilities, providing the capability to use the 4-ESG MEB against a robust enemy. Additionally, all ships are built to NAVSEA survivability standards and have large, well-trained damage control teams to limit any damage to the ships from enemy action.

4.8 ESG Cost Data

Since the MEUs and ESGs already exist, the cost estimate includes only Operations and Support (O & S) only; the acquisitions costs are considered sunk costs and are not included. The cost to operate 4 ESGs is about $1-1.5 billion per year. Therefore, the cost of 4 ESGs for the 10-year period 2004-2015, is approximately $10 billion-$15 billion (FY04$).

4.9 U.S. Army Expeditionary Brigade

The U.S. Army's 82nd Airborne Division asserts that it can deploy a third of their Division's 14,000-man strong combat power within 18 hrs by parachutes from C-17 or C-130 aircraft.[92] Historically, a third of the Division is on ready alert, a third in a training status, and the last a third is ready to provide logistical support to speed deployment of the ready unit. The 82nd Airborne is light by design, taking only what can be rapidly mobilized and parachuted with the combat troops. One hundred paratroopers will fit on a C-17. Approximately 45 C-17 flights are required to deploy the 4,600 troops alone.

The Army's Stryker Brigade, a heavier, mechanized force than the 82nd Airborne, advertises 350 C-17 sorties[93] to deliver its troops and equipment. This gives an idea of the magnitude of the strategic airlift required to move a mechanized brigade. After initial

[92] "82nd Airborne Division," (02 August 2004 [cited 20 November 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/agency/army/82abn.htm.
[93] "Joint Military Operations Brief," Headquarters, Department of the Army, (26 August 2004 [cited 03 December 2004]).

assault, the deployed troops must secure an airfield to receive logistical support and any heavy assault vehicles needed. This need for an airfield limits their mobility and ability to assault heavily armored enemy forces.

4.10 2004 Gap Summary

No joint, seabased expeditionary force exists today that meets the requirements in the FAA. The closest approximation of the seabased JEB is a 4-ESG, 4-MEU unit. Even with optimistic positioning and readiness assumptions, this force closes the AO in 25-30 days—15-20 days slower than the 10-day requirement. This force employs to the beach/objective in 5 days from the desired range of 25 NM—4 2/3rd days longer than the 10-hr requirement. This force is only able to self-sustain for a maximum of 15 days—15 days less than the 30-day requirement.

Army expeditionary forces, while able to close and employ very light forces by air within the 10-day requirement, cannot bring their heavier units of combat power in that same time. Once employed, the Army expeditionary forces are critically dependent on an airfield and/or a developed port facility to sustain their troops. For this reason, they do not meet the austere access criteria that led to the Sea Base concept.

Enclosure 1: MEU Closure Calculations

From	To	Distance	Time
BAH (26°16'15"N 50°38'01"E)	KHS (26°10'16"N 56°14'26"E)	303 nm	15:08
KHS (26°10'16"N 56°14'26"E)	CMB (07°10'52"N 79°53'02"E)	1766 nm	88:18
CMB (07°10'52"N 79°53'02"E)	RGN (16°54'26"N 96°08'00"E)	1117 nm	55:51
Total:		3185 nm	159:16

Time-Speed-Distance for ESG from Persian Gulf to Myanmar.

From	To	Distance	Time
NGS (32°55'01"N 129°54'49"E)	DNA (26°21'20"N 127°46'03"E)	408 nm	20:25
DNA (26°21'20"N 127°46'03"E)	SIN (01°21'21"N 103°59'15"E)	2030 nm	101:29
SIN (01°21'21"N 103°59'15"E)	RGN (16°54'26"N 96°08'00"E)	1038 nm	51:55
Total:		3477 nm	173:50

Time-Speed-Distance for ESG from Japan to Myanmar.

From	To	Distance	Time
NSY (37°24'06"N 14°55'20"E)	PSD (31°16'46"N 32°14'24"E)	933 nm	46:40
PSD (31°16'46"N 32°14'24"E)	JIB (11°32'50"N 43°09'34"E)	1327 nm	66:20
JIB (11°32'50"N 43°09'34"E)	CMB (07°10'52"N 79°53'02"E)	2192 nm	109:37
CMB (07°10'52"N 79°53'02"E)	RGN (16°54'26"N 96°08'00"E)	1117 nm	55:51
Total:		5569 nm	278:27

Time-Speed-Distance for ESG from Mediterranean Sea to Myanmar.

From	To	Distance	Time
SAN (32°44'01"N 117°11'23"W)	MUE (20°00'05"N 155°40'05"W)	2195 nm	109:44
MUE (20°00'05"N 155°40'05"W)	GUM (13°29'00"N 144°47'46"E)	3433 nm	171:40
GUM (13°29'00"N 144°47'46"E)	MNL (14°30'31"N 121°01'10"E)	1388 nm	69:23
MNL (14°30'31"N 121°01'10"E)	SIN (01°21'21"N 103°59'15"E)	1281 nm	64:02
SIN (01°21'21"N 103°59'15"E)	RGN (16°54'26"N 96°08'00"E)	1038 nm	51:55
Total:		9335 nm	466:45

Time-Speed-Distance for ESG from San Diego to Myanmar.

From	To	Distance	Time
NGU (36°56'16"N 76°17'22"W)	GIB (36°09'04"N 05°20'59"W)	3345 nm	167:14
GIB (36°09'04"N 05°20'59"W)	PSD (31°16'46"N 32°14'24"E)	1892 nm	94:36
PSD (31°16'46"N 32°14'24"E)	JIB (11°32'50"N 43°09'34"E)	1327 nm	66:20
JIB (11°32'50"N 43°09'34"E)	CMB (07°10'52"N 79°53'02"E)	2192 nm	109:37
CMB (07°10'52"N 79°53'02"E)	CBD (09°09'12"N 92°49'10"E)	779 nm	38:56
CBD (09°09'12"N 92°49'10"E)	RGN (16°54'26"N 96°08'00"E)	502 nm	25:06
Total:		10036 nm	501:49

Time-Speed-Distance for ESG from Norfolk to Myanmar.

5. 2015 BASELINE ARCHITECTURE DESCRIPTION

5.1 Overview

This chapter describes the process used to define the 2015 Baseline Architecture (2015 BLA). The 2015 BLA is limited to systems and platforms that are Programs of Record,[94] as of Fiscal Year (FY) 2004, and those that are currently in inventory and expected to remain active through the 2015 time frame.

The 2015 BLA is developed using the vision of the Joint Expeditionary Logistics (JELo) Operating Concept [Chapter 2] and the JELo Functional Area Analysis (FAA) [Chapter 3]. As mentioned in Chapter 1, SEA-6 uses the 2015 BLA to identify, analyze, and quantify capability gaps. The steps taken to define the 2015 BLA include determining:

- the scope and assumptions;
- the methodology to down-select systems and platforms;
- the architecture views, based on the Department of Defense Architecture Framework (DODAF);[95]
- the force structure of the specific components (U.S. Army (USA), U.S. Navy (USN), U.S. Air Force (USAF), and U.S. Marine Corps (USMC));
- the Maritime Prepositioning Force, Future (MPF(F)) vessel;[96]
- the platforms eliminated from the 2015 baseline composition;
- the composition of the 2015 Baseline Architecture;
- the distribution of air assets among the MPF(F) ships; and
- the 2015 Baseline Architecture Concept of Operations.

[94] For the purpose of this study, a Program of Record is defined as any Department of Defense (DoD) program that has an established program office and manager.
[95] DoD Architecture Framework Working Group, "DoD Architecture Framework (DODAF)[95] Version 1.0, Vol. I: Definitions and Guidelines," 15 August 2003.
[96] Robert M. Souders, Suzanne Schulze, Yana Ginburg, and John Goetke, "MPF(F) Analysis of Alternatives: Final Summary Report," (Alexandria, VA: The CNA Corporation, CNR D0009814.A2/Final, April 2004).

SEA-6 is organized into four functional teams: Connectors, Transfers, Command and Control (C2), and Inventory and Storage (I & S). This chapter is organized in the same manner:

- Connectors are modes of transport carrying assault troops, medical patients, cargo, and equipment. Section 5.8 of this chapter discusses Connectors.
- Transfers are the physical systems or equipment that moves these same items between Connectors or between Connectors and the objective. Section 5.9 of this chapter discusses Transfers.
- C2 is the information system that is established to facilitate the coordination of these operations. Section 5.10 of this chapter discusses C2.
- Inventory and Storage include systems and processes that enable cargo and equipment to be stored and moved within the Sea Base platforms. Section 5.11 of this chapter addresses other functions and provides a more detailed and precise definition of Inventory and Storage.

Defining the 2015 BLA includes determining the Joint Expeditionary Brigade (JEB) force structure, the platforms and systems to support the JEB, and the concept of operations for that collection of people and equipment. The platforms and systems considered for the 2015 BLA are limited to those currently in the inventory and expected to remain active through the 2015 time frame, and Programs of Record as of FY04.

Funded and unfunded future concepts, including Advanced Concept Technology Demonstrations (ACTDs) and Advanced Concept Demonstrations (ACDs) are not considered for the 2015 BLA. Although no specific MPF(F) ship designs are Programs of Record, for the purpose of conducting analysis, the MPF(F) design[97] chosen by SEA-6 is considered a Program of Record.

[97] Souders et al., 2004.

Equipment and personnel from either the in-theater Carrier Strike Group (CSG) or Expeditionary Strike Group (ESG) are considered outside the scope of the 2015 BLA. Although part of the Sea Base, both are assumed to have their own logistics infrastructure. The JEB will not be employed in sea state greater than 4. Budgetary constraints limit materiel selections.

The 2015 BLA is developed to meet the following key requirements from the FAA [Chapter 3]:

- Must support a JEB of approximately 14,500 personnel.[98]
- Preliminary forces deploy to the objective within ten days.
- Preliminary elements deploy from the Sea Base to the objective within one 10-hr period of darkness.
- MPF(F) ships have 30 days' worth of food, water, fuel, and ammunition on board.
- The JEB must be sustained for 30 days.
- MPF(F) ships maintain a 50% reserve of food, water, fuel, and ammunition on board.

The following assumptions are made in determining the 2015 BLA:

- All Programs of Record platforms/equipment considered and chosen by SEA-6 are fielded.
- The chosen MPF(F) design includes selective offload capability with sufficient space to access cargo using current methods.
- MPF(F) ships replace current Maritime Prepositioning Squadron (MPS) ships at the Forward Logistics Site s(FLSs) of Guam and Diego Garcia.

[98] "MPF(F) 101 Brief," slides 22-28 (January 2003 [cited 18 August 2004]); available from the World Wide Web @ http://hqinet001.hqmc.usmc.mil/pp&o/POE/POE-60/MPF-F/Updated2015MPF(F)MEB.ppt.

- MPF(F) ships are based at the same FLS as current MPF ships (Guam, Diego Garcia, Sigonella), but may be underway in the vicinity of the FLS.
- Port facilities/airfields are not initially available at the objective, but may be taken as an objective for sustainment.
- Equipment and personnel supported from the Sea Base are provided from the MPF(F) ships.
- The JEB has common supplies and equipment common to any service.
- USA JEB requires USN and USMC Sea Base personnel and connectors for support and transport.
- Sea Strike and Sea Shield establish maritime dominance and air supremacy by the time the Sea Base assets arrive in the AO.
- Naval Special Operations Force (SOF) components are based on the CSG or ESG and not on the MPF(F).
- Landing Craft, Air Cushion (LCACs) are forward deployed at the FLS
- The MPF(F) assault connectors support the JEB and are not otherwise tasked.
- MV-22 and F-35 (Joint Strike Fighter (JSF)) aircraft self-deploy to either the FLS or directly to the MPF(F) ships.
- Helicopters are airlifted to the FLS.
- Military forces use a single type of fuel by 2015.
- The JEB deploys from the closest forward base to the AO.
- Any mission requiring the rapid deployment of a JEB has sufficient priority to get the strategic tanking and Air Mobility Command (AMC) airlift in time to meet their deployment timeline.

The 2015 BLA is designed to meet the key requirements using the systems currently being discussed for Sea Base force planning: current systems expected to continue operation into 2015 and Programs of Record systems (FY04). The JEB force is defined in detail as input to determine the composition of platforms and systems required

to support them. A Concept of Operations that describes how the platforms and systems function together to perform the mission is defined in Chapter 3. Platform and system characteristics, such as fuel burn rate, material capacity, and range, are researched to determine various logistical requirements.

A JEB as described in the Operating Concept [Chapter 3] is not yet developed. The Marine Corps, however, defines an expeditionary brigade to the level of detail required to pursue this study. To quantify the JEB logistics footprint, SEA-6 uses a Marine Expeditionary Brigade (MEB) as a surrogate. SEA-6 does not claim that this is the force of the future, or that it is the optimum force. No attempt is made to analyze or develop alternative forces from a combat effectiveness perspective.

The Marine Corps Combat Development Command (MCCDC) generated spreadsheets of the 2015 MPF(F) MEB equipment items broken down by Sea Base Maneuver Element (SBME), Sea Base Support Element (SBSE), Sustained Operations Ashore Element (SOAE), and the Forward Base Echelon (FBE) [Enclosures 1A and 1B]. These spreadsheets provide needed information to calculate load and ship capacity requirements. The total number of MPF(F) ships is derived from the information contained in these sources.

SEA-6 evaluates the USMC 2015 MPF(F) MEB concept and the USA Brigade Combat Team (BCT) concept as logistical surrogates for a JEB combat force. Both concepts are designed to the same set of missions. No effort is made to determine which force is more effective. Predicted compatibilities are used for analysis to the degree to which the concepts were defined in the literature.

5.2 U.S. Air Force

The Closure phase described in the Operating Concept [Chapter 3] may rely on strategic airlift and aerial refueling to get the aircraft to the FLS. The assets required for this mission have traditionally come from the USAF AMC.

USAF future plans indicate that there will be 126 C-5[99] and 180 C-17[100] aircraft in the 2015 time frame and that AMC will provide the necessary assets to accomplish the Sea Base mission. This assumption is optimistic; in Desert Storm, USMC aircraft waited for days for airlift and aerial refueling support into theater.[101]

5.3 U.S. Marine Corps

The USMC has published a detailed description of their envisioned 2015 Baseline MEB Organization.[102] The 2015 MEB consists of two possible configurations: an Amphibious MEB and a MPF(F) MEB. SEA-6 selects the MPF(F) MEB for the 2015 BLA.

The MPF(F) MEB consists of four distinct elements: the Sea Base Maneuver Element (SBME), the Sea Base Support Element (SBSE), the Sustained Operations Ashore Echelon (SOAE), and the Forward Base Echelon (FBE). The MEB to be stationed and transported on the Sea Base is the combat element of approximately 4,900, the support element of approximately 3,200,[103] a USN element of approximately 1,200,[104] and a Joint Staff comprised of approximately 500 mixed-service personnel.[105] The current USMC concept says the 2,200 personnel of the FBE and the 4,200 of the SOAE are not onboard the Sea Base, but their equipment is onboard and can be transferred ashore if needed.

The personnel of the SBME and SBSE are transported to the FLS for onward movement to the MPF(F) ships. According to the USMC 2015 Baseline MEB organization, the majority of the MEB equipment is prepositioned on the MPF(F) ships.[106] The USMC does not envision operating the FBE and SOAE from the Sea Base,

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99 "C-5 Galaxy," (August 2003 [cited 12 October 2004]); available from the World Wide Web @ http://www.af.mil/factsheets/factsheet.asp?fsID=84.
100 "C-17 Globemaster III,"(October 2004 [cited 12 October 2004]); available from the World Wide Web @ http://www.af.mil/factsheets/factsheet.asp?fsID=86.
101 Hopkins, J.I., MGen, USMC, "This Was No Drill," appearing in *Proceedings*, November 1991.
102 Update "Baseline" 2015 MEB Organization, pp. 22-28.
103 Ibid.
104 MCCDC Concepts Branch Futures Division, "Baseline 2015 MEB," 24 January 2003, p. 37.
105 Souders et al., p. 24.
106 Ibid.

however, as their equipment is positioned on the MPF(F), SEA-6 uses it in the sizing of the Maritime Prepositioning Group (MPG).

5.3.1 Sea Base Maneuver Element

The SBME is the force necessary to conduct Operational Maneuver from the Sea (OMFTS)/Ship to Objective Maneuver (STOM) operations by maneuvering from the Sea Base. There are 4,859 personnel in this element, organized into 2 surface Battalion Landing Teams (BLT) and 1 vertical BLT.[107] Mr. Jeffrey Koleser from Naval Sea Systems Command (NAVSEA) provided SEA-6 with spreadsheets developed in 2004 by the Naval War College and the Navy Warfare Development Command detailing the equipment and troops for the surface BLT shown in Enclosure 1A (SBME Equipment Breakdown (surface BLT)). SEA-6 developed the vertical BLT, shown in Enclosure 1B (SBME Equipment Breakdown (vertical BLT), by subtracting the surface BLT from the total MEB equipment contained in the MCCDC Baseline 2015 MEB.[108]

The SBME is further divided into initial and follow-on forces. The initial force, consisting of both surface BLTs and the vertical BLT (4,300 personnel), deploys with their associated equipment, detailed in Enclosure 1A as landing priorities 1-19 and Enclosure 1B as landing priorities 1-8. This initial landing priority includes the only portion of the force constrained by the one period of darkness employment. The follow-on force, consisting of 540 support personnel and the remaining equipment landing priorities of Enclosures 1A and 1B, deploys prior to the initial force's supply depletion. A summary of the Marine equipment transported ashore is displayed in Table 5-1.

[107] Ibid.
[108] Ibid.

Vehicles	Surface BLT (Initial)	Vertical BLT (Initial)	Surface BLT (Follow-On)	Vertical BLT (Follow-On)	Total Equipment	Surface BLT Personnel (Initial)	Vertical BLT Personnel (Initial)	Surface BLT Personnel (Follow-On)	Vertical BLT Personnel (Follow-On)	Total Personnel
4K Forklift	8				8	8				8
Assault Breaching Vehicle (ABV)	4				4	16				16
AN/TPQ (4 HMMWV & 4 Trlr)	2				2	24				24
Avenger	10				10	20				20
Armored Vehicle Launched Bridge (AVLB)	2				2	8				8
Contact Truck	4		14		18	16		20		36
D7 Bulldozer			2		2			2		2
Expeditionary Fire Support System (EFSS)		8			8		8			8
Expeditionary Fighting Vehicle (EFV)	98		8		106	1,760		40		1,800
High Mobility Artillery Rocket System (HIMARS)			18		18			54		54
Internally Transportable Vehicle (ITV)	16				16	48				48
Light Armored Vehicle (LAV)	50	25	6	3	84	210	105	12	6	333
Logistics Vehicle System (LVS)			36		36			76		76
High Mobility Multipurpose Wheeled Vehicle (HMMWV)	162	129	54	14	359	588	1071	134	22	1,815
HMMWV with Trailer	42		12		54	118		32		150
M1A1 Abrams Main Battle Tank	20				20	80				80
M1A1 w/ Track Width Mine Plow (TWMP)	8				8	32				32
M88A2 Recovery Vehicle	2		2		4	10		8		18
M9 Armored Combat Earthmover (ACE)	8				8	8				8
Medium Tactical Vehicle Replacement (MTVR)	2		6		8	8		16		24
MTVR with Trailer	36		46		82	162		118		280
Trlr, Lowbed			2		2			0		0
Total	474	162	206	17	859	3,116	1184	512	28	4,840

Table 5-1: Summary of MEB equipment and personnel.

Each surface BLT consists of 1 infantry battalion, 1 artillery battery, 1 tank company, 1 amphibious assault company, 1 light armored reconnaissance company, 2 combat engineer platoons, 1 detachment engineer support company, 1 air defense section, and 1 direct support (infantry battalion). The vertical BLT consists of 1 infantry battalion, 1 Expeditionary Fire Support System (EFSS) battery, 2 combat engineer platoons, 1 air defense section, and 1 direct support (infantry battalion). The SBME is comprised of 3 maneuver elements; all SBME equipment and personnel are located on the MPF(F) ships.

5.3.2 Sea Base Support Element

The SBSE is defined as the personnel and services necessary to provide sea based support (C2, aviation, logistics, and base support) to maneuver units conducting OMFTS/STOM operations ashore. There are 3,203 personnel in this element, comprised of a MEB Command Element, Ground Combat Support Elements and the Sea Base Air

Combat Element (ACE). The Sea Base ACE is comprised of 48 MV-22s, 18 AH-1s, 9 UH-1s, 20 CH-53s, 6 Vertical Takeoff Unmanned Aerial Vehicles (VTUAVs), 36 F-35s, and the Sea Base ACE Direct Support Company. The SBSE equipment and personnel remain on the MPF(F) ships.

5.3.3 Sustained Operations Ashore Echelon (SOAE)

The SOAE represents the capabilities necessary to transition from OMFTS/STOM operations to Sustained Operations Ashore (additional logistics, C2, and infrastructure). The SOAE equipment is located on the MPF(F) ships and is not configured for selective offload; it requires a port facility be secured to offload. The SOAE personnel are on alert at home station (or at a base located closer to, but not within, the AO). The Command Element and Brigade Service Support Group forces total 4,199 personnel. These forces are brought in when, and if, the rapid maneuver operations ashore transition to sustained operations ashore.

5.3.4 Forward Base Echelon

The FBE is the basing for the non-Sea Base MEB ACE and Air Port of Debarkation (APOD) functions. There are 2,223 personnel in this element, organized into KC-130, EA-6B, and F-35 squadrons (as necessary), as well as Airbase Support and Operations personnel and a non-Sea Base ACE Direct Support Company. The FBE equipment is located on the MPF(F) ships (with the exception of aircraft) and the personnel are located within the JOA, but not actually on the Sea Base ships. The FBE requires a land-based airfield. This element is not part of the Sea Based operations that SEA-6 is considering.

5.4 U.S. Army

The Army's expeditionary force concept is the 2010-2020 Army Objective Force.[109] This force is organized into a Brigade Combat Team (BCT) that is composed of

[109] Army Training and Doctrine Command (TRADOC), "The United States Army Objective Force Operational and Organizational Plan Maneuver Unit of Action," Unit of Action Maneuver Battle Lab, Change 2 to the Army Training and Doctrine Command (TRADOC) Pamphlet 525-3-90 O & O, 30 June 2003.

various service elements. In a small-scale contingency, one or more BCTs could operate under a Joint Task Force (JTF).[110] A single Army BCT is roughly equivalent to a USMC MEB. Although the Army describes their BCT concept in some detail, much of their equipment is still under development; exact sizes and weights have not been determined. The Marine Corps, however, has published a detailed description of their envisioned 2015 Baseline MEB Organization, including personnel numbers and specific equipment lists. Because the Marine Corps has defined the necessary details for analysis, SEA-6 uses the 2015 MEB as the logistical equivalent of a JEB. However, based on a comparison of troops and equipment, an architecture that can move and sustain a MEB can support other comparable size forces.

5.4.1 Brigade Combat Team Design

The BCT Increment 1 Threshold design shown in Figure 5-1 (scheduled to be operational by the 2010-2012 time frame) consists of 6 major unit types totaling 2,976 soldiers and approximately 1,530 platforms/equipment.[111] The personnel numbers shown in Figure 5-1 belong to each of the major units, identified as 1 headquarters company (HHC), 1 brigade intelligence and communication (BIC) company, 3 combined arms (CA) battalions, 1 aviation squadron, 1 non-line-of-sight (NLOS) battalion, and 1 forward support battalion (FSB).

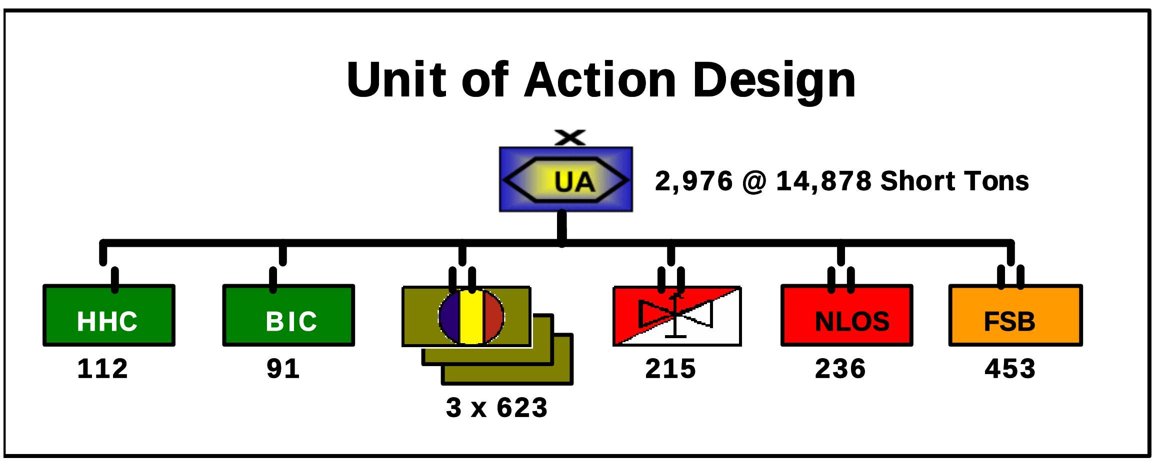

Figure 5-1: Army Brigade Combat Team Increment 1 Threshold Design.[112]

[110] Ibid., p. 1-3.
[111] Ibid., pp. 3-1, 3-2.
[112] Ibid., p. 3-60.

5.4.2 Brigade Combat Team Deployment

The Army does not currently envision prepositioning the BCT equipment on MPF ships; the BCT equipment deploys with the troops via airlift from their home base. This force is designed to be transportable by several different aircraft and ships, including the C-130 and the Theater Support Vessel (TSV).[113] The Army deployment vision is to arrive in the AO within 96 hrs of transport vehicle departure. This transportable design lends itself to Sea Base operations. If the JEB is comprised of an Army BCT, it is transported, with equipment, via strategic airlift from their home base to the FLS, where they will board the MPF(F) ships.

5.4.3 Brigade Combat Team Required Support

The BCT requires external support in the following areas: employment transportation, information superiority, battle space preparation, sustainment, air and missile defense, long-range fires, explosive ordnance disposal (EOD), engineer assets, casualty evacuation, and aircraft for air assault operations.[114] Sea Strike conducted by CSG forces covers some of these missions and some are covered by the Navy personnel assigned to the MPF(F); however, some entail having additional units assigned stationed aboard the MPG (such as JSF, air and surface connectors). For the purpose of this analysis, USMC assault connectors (CH-53X, MV-22, AH-1Z, LCAC, etc.) are assigned and fulfill the sustainment, casualty evacuation and transportation needs and that the other units of the Sea Base provide the remaining support.

5.4.4 Unit of Action Resupply

The BCT is designed to carry supplies for three days of medium to intense combat or up to 7 days of low combat operations.[115] The Army's vision is to have the BCT resupply by aerial delivery. For the purpose of this study, extended BCT operations will require resupply from the MPF(F) via its connectors. It is assumed that if a MEB can be supported, the Army BCT can also be supported.

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[113] Ibid., p. 1-6.
[114] Ibid., pp. 1-6, 1-7.
[115] Ibid., pp. 4-18, 4-19.

5.4.5 Brigade Combat Team Equipment

The Army estimates the BCT equipment weight to be 14,878 short tons.[116] Quantities of equipment assigned to specific units with their personnel numbers are broken down in Enclosure 2 (Army BCT Equipment Breakdown). Specific size and weight information is not yet available.

5.5 U.S. Navy

Both the MEB and the BCT need a Naval Support Element (NSE) to accomplish the mission.

5.5.1 Naval Support Element

For each MPG deployed, a NSE consisting of approximately 1,200[117] personnel is required for such tasks as LCAC crews, Underway Replenishment (UNREP) details, medical personnel, etc. The 1,200 personnel are distributed across the MPF(F) ships, including not less than 2 crews per LCAC. Each LCAC crew consists of 5 persons, totaling 30 persons per MPF(F) ship specifically allocated for the operation of the three LCACs that can be carried onboard each of the MPF(F) ships. Additionally, the NSE contains approximately 100 personnel specifically dedicated to provide both routine and emergency medical care of the combat forces.[118]

The USAF AMC, and the USN NSE and Joint Task Force Staff,[119] comprised of approximately 500 mixed-service personnel, are considered as supporting forces.

5.6 Maritime Prepositioning Force, Future

The functional core of the 2015 BLA is the MPF(F) ship. Only designs from the Center for Naval Analysis (CNA) MPF(F) Analysis of Alternatives: Final Summary

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[116] Ibid., p. 3-60.
[117] "Baseline 2015 MEB," Power Point brief from MCCDC Concepts Branch Futures Division, 24 January 2003, p. 37.
[118] Neil Carey, James Grefer, Robert Trost, and Robert Levy, "Future Deployable medical Capabilities and Platforms for Navy Medicine," (Alexandria, VA: The CNA Corporation, CRM D0005085.A2/Final February 2002), pp. 61-63.
[119] Souders et al., p. 24.

Report[120] are considered. Table 5-2 lists the characteristics of these ships. The CNA study refers to their ship design concepts as either constrained or unconstrained in size and either distributed capability or families of specialized ships. The constrained size indicates that any of the expected U.S. shipyards would have the capability of building the ship. The unconstrained size refers to the inability of at least one of the expected U.S. shipyards to build the design. Distributed capability refers to ships built to the same design with the forces and equipment distributed among the ships. Families of specialized ships refer to a squadron composed of several different types of ships, each of which are specialized for a particular function (i.e., aviation and command ships, logistics ships, personnel ships, etc.).

Consistent with the Marines' desire to avoid a single point of failure,[121] SEA-6 eliminated the families of specialized ships. Of the remaining designs, only those capable of carrying a JEB with its associated aircraft are considered. The two constrained-size, distributed-capability ship designs could not fully support the Sea Base requirements across all envisioned functional areas. One of the constrained-size designs was not capable of operating the F-35 aircraft.[122] The other design had insufficient surface craft stowage.[123]

Of those remaining, SEA-6 compares the cargo volume, area, weight and personnel numbers. Cargo area and total JEB personnel requirements drive the selection. The unconstrained ship design[124] is chosen based on the ability to carry the entire JEB in the fewest number of ships. Eight of these ships are required to carry the JEB.

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[120] Souders et al., pp. 33-46.

[121] Roxana Tiron, "Navy Downsizing Could Weaken Marine Corps Expeditionary Posture," in National Defense, para. 23 [online journal] (August 2004 [cited 05 November 2004]); available from World Wide Web @ http://www.nationaldefensemagazine.org/article.cfm?Id=1538.

[122] Souders et al., p. 36.

[123] Ibid., p. 35.

[124] Unconstrained-size, distributed-capability, as defined in the CNA study refers to their design concept. Constrained-size would indicate that any of the expected U.S. shipyards would have the capability of building the ship. Unconstrained-size refers to the inability of at least one of the expected U.S. shipyards to build the design. Distributed-capability refers to ships built to the same design with the forces and equipment distributed among the ships.

Ship Type	Large Medium Speed RO/RO	Clean-Sheet	Unconstrained Size	Constrained Size	Aviation/C2	Logistics Ship	RO/RO Personnell	Unconstrained Logistics RO/RO	Constrained Logistics RO/RO	Afloat Forward Staging Base
# Combat Personnel	50	50	2,020	1,430	2,100	670	1,311	1,570	1,085	2,000
# Ship Crew	45	45	80	80	49	59	80	80	59	45
Cargo Weight (tons)	33,705	26,202	23,838	16,880	13,884	14,972	20,594	24,090	32,845	Unknown
Cargo Size (sq ft)	184,000	184,000	213,000	144,000	17,000	0	4,300	280,000	194,200	33,000
Cargo Area (sq ft)	0	0	18,300	11,400	12,900	24,000	367,000	14,500	23,500	30,000
# MV-22s	0	0	21	13	40	0	0	0	0	36
# CH-53s	1	1	5	4	6	1	3	2	1	11
LCAC stows	0	0	3	2	0	0	6	4	3	0
Total People	1	1	1	1	1	1	1	1	1	1
WEIGHT (tons)	0	0	0	0	0	0	0	0	0	Unknown
SQUARE (Feet)	0	0	0	0	0	0	0	0	0	0
MV-22	0	0	0	0	0	0	0	0	0	0
CH-53	0	0	0	0	0	0	0	0	0	0
LCAC	0	0	0	0	0	0	0	0	0	0

Table 5-2: Comparison of MPF(F) alternate ship designs.

Figure 5-2 shows the chosen MPF(F) ship. Table 5-3 shows the detailed characteristics of the unconstrained-size, distributed-capability MPF(F).[125]

Figure 5-2: Chosen MPF(F) Ship.[126]

Although there are five spots for normal air operations, because vertical replenishments require additional flight deck space, only two vertical replenishments can be accomplished simultaneously.[127]

[125] Ibid., p. 34.
[126] Ibid., p. 34.

	Unit	Dimension
Length overall	ft	1,030
Maximum beam	ft	202
Full load draft	ft	34.8
Lightship tonnage	MT	61,179
Full-load tonnage	MT	82,850
Full time MSC crew	Number of personnel	80
USMC accommodations	Number of personnel	2,020
Cargo fuel	bbls	44,600
Cargo square	sq ft	213,000
Cargo area	sq ft	18,300
Number of containers	Number of TEUs	238
Aviation stowage and maintenance space	sq ft	158,700
CH-46 equivalent parking spots	Number of spots	47
CH-53 operational spots	Number of spots	5
LCAC stows	Number of stows	3
Craft interface	Number of interfaces	1
Detailed Information per Ship		
Personnel berthing space	2,020 people	
Vehicle cargo space	213,000 sq ft	
Combat gear space (nonvehicle)	18,300 sq ft	
Aircraft storage space	108,700 sq ft	
Surface craft storage space	3 LCACs	
Medical space	5,000 sq ft	
Maintenance space	50,000 sq ft	
Assembly space	7,000 sq ft	
Fuel space	44,600 bbls	
Interface (Surface)	1	
Interface (Vertical)	2	
Water production	500,000 gal/day	
Additional Squadron Requirements		
Non-Prepositioned cargo	3,000 tons	
JTFC Staff Personnel	500 people	
JTFC Staff space	30,000 sq ft	
MEB C2 space	30,000 sq ft (split across two ships)	

Table 5-3: Breakdown of chosen MPF(F) ship.[128]

The eight ships are each loaded with complete JEB sub-units (i.e., rifle company, tank battalion, artillery battery, etc.). The eight distributed-capability ships provide the maximum number of simultaneous surface and vertical connector interfaces for employment of the force to the objective.

[127] Souders et al., pp. 34-35.
[128] Ibid., p. 35.

5.7 2015 Baseline Architecture Composition

The 2015 BLA composition consists of a MPF(F) squadron of 8 ships, 1 resupply ship, 26 surface assault connectors, 77 air assault connectors, and 70 nonconnector air assets. Although no plans exist to forward deploy a CLF asset specifically designated to support the MPG, SEA-6 preliminary analysis demonstrated the need for a Combat Logistics Force (CLF)-capable ship to refuel the MPF(F) ships. To meet the requirement for 30 days of sustainment, SEA-6 includes 1 CLF asset in the 2015 BLA composition. The remainder of this section describes the functional subsystems: Connectors, Transfers, C2, and Inventory and Storage.

5.8 Connectors

Connectors are modes of transport that carry assault troops, medical patients, cargo, and equipment. Based on open literature and internal analysis, the SEA-6 Connectors Team assesses the characteristics of the connectors to be as described below. The cargo capacities listed are not necessarily the rated capacities, but are calculated capacities, based on standard packaging of food, water, ammunition, and fuel. The quantity of each type of connector is taken from the MCCDC 2015 Baseline MEB Organization,[129] MPF 2010 Ship-to-shore Movement, Seabased Logistics Support,[130] and the CNA MPF(F) study.[131]

5.8.1 Maritime Prepositioning Group (MPG)

The MPG consists of a squadron of eight MPF(F) ships along with a supporting CLF ship and two Landing Craft Utility, Replacement (LCU(R)) ships. Speed of advance for the MPF(F) is expected to be around 20-22 kts.

One Fast Combat Support Ship (T-AOE). The T-AOE is the Navy's largest combat logistics ship possessing the speed to keep up with the MPG. It can rapidly replenish ships and carries more than 156,000 bbls of fuel, 1,800 tons of ammunition, and

[129] MPF(F) 101 Brief, pp. 22-28.
[130] Keith R. McAllister, "MPF 2010 Ship-to-shore Movement and Sea-based Logistics Support Volume 1: Report," (Alexandria, VA: The CNA Corporation, May 1998).
[131] Souders et al.

650 tons of stores.[132] The T-AOE can simultaneously service 2 ships, 1 on either side. The T-AOE has 2 SH-60R helicopters embarked for conducting vertical replenishment (VERTREP).

Two Landing Craft Utility, Replacement (LCU(R)) ships. The LCU(R)s are chosen for inclusion in the 2015 baseline composition as they are capable of sustained sea operations for approximately 10 days[133] and are assumed to be capable of operation in higher sea states than the LCAC. It is assumed that the LCU(R) is capable of in transit refueling from either the MPF(F) or CLF ship. These LCU(R)s will self-deploy from the FLS and will be used to transport equipment (tanks, artillery, equipment, motor vehicles—tracked or wheeled) and troops to the shore. LCU(R) characteristics:

- Cargo Area Dimension: 2,800 sq ft
- Weight Capacity: 495,000 lbs
- Class I Cargo (food): 411,945 lbs of Meals, Ready-to-Eat (MREs)
- Liquid Cargo Class III (fuel): 18,000 gals
- Liquid Cargo Class I (water): 56,160 gals
- Class V (artillery ammunition): 316,176 lbs
- Class V (small Arms ammunition): 493,920 lbs
- Speed: 36 kts (kts) maximum intermittent speed, 30 kts cruise. Assume all loads are moved at 30 kts
- Range: ~ 900 nautical miles (NM) averaging 28 kts

5.8.2 Surface Assault Connectors

Surface assault connector characteristics are taken from the sources listed in Section 5.8 of this chapter.

[132] Schrady et al., pp. 7-9.
[133] "Landing Craft Utility (LCU)," (18 August 2004 [cited]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ship/lcu.htm.

Twenty-four LCACs. The LCAC is the primary surface assault Connector capable of transporting weapons systems, equipment, cargo and personnel of the assault elements of the brigade-sized force both from ship to shore and across the beach. The LCAC is a high-speed, over-the-beach, fully amphibious landing craft, capable of carrying a 60-75 ton payload.[134] LCAC characteristics:

- Cargo Area Dimension: 1,809 sq ft
- Weight Capacity: 120,000 lbs
- Class I Cargo (food): 119,442 lbs of MREs
- Liquid Cargo Class III (fuel): 6,000 gals
- Liquid Cargo Class I (water): 13,500 gals
- Class V (artillery ammunition): 116,684 lbs
- Class V (small Arms ammunition): 117,600 lbs
- Speed: 40 kts with payload, sea state 2. Above sea state 2 planning speed is 25 kts fully loaded. Operations > sea state 4 are precluded.
- Range: sea state ≤ 2 = 200 NM at 40 kts fully loaded, 300 NM at 35 kts empty. Sea state ≤ 3 = 300 NM at 25 kts fully loaded. Sea state > 4 operations precluded.
- Troops: 180 with Personnel Transport Module (PTM). This module is installed on the LCAC during transportation of troops. If not needed, it will be stowed in the LCAC deck spot onboard the MPF(F) ship.

5.8.3 Air Assault Connectors

The number and type of air assault connectors are taken from USMC sources. It is important to note that the air assault connector numbers mentioned here are not the maximum number of air connectors that the 2015 BLA MPG is capable of transporting; it has sufficient deck space to transport 45 additional MV-22s or 37 additional CH-53s.

[134] "Landing Craft, Air Cushion (LCAC)," (17 July 2004 [cited 02 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ship/lcac.htm.

Forty-eight MV-22s (Marine Corps version of the V-22 Osprey). The MV-22 is a tilt rotor, vertical/short takeoff and landing (VSTOL), multimission aircraft developed to fill multiservice combat operational requirements. The MV-22 is the Marine Corps' assault helicopter in the medium lift category contributing to the dominant maneuver of the Marine landing force, as well as supporting focused logistics in the days following commencement of an amphibious operation. The tilt rotor design combines the vertical flight capabilities of a helicopter with the speed and range of a turboprop airplane and permits aerial refueling and worldwide self-deployment.[135] MV-22 characteristics:

- Cargo Area Dimension: 5.4 ft high, 5.7 ft wide, 16.84 ft long
- External Weight Capacity: 10,000 lbs
- Internal Capacity limited to troop movement only
- Class I Cargo (food): 9,982 lbs of MREs
- Liquid Cargo Class III (fuel): 1,000 gals
- Liquid Cargo Class I (water): 1,080 gals
- Class V (artillery ammunition): 7,528 lbs
- Class V (small arms ammunition): 6,720 lbs
- Speed: With max external load (pallets): 150 kts; with max external load (vehicle): 110 kts
- Speed: With max internal load: 234 kts
- Range: External Load: 290 NM; Internal Load: 530 NM
- Troops: 24

Twenty CH-53X Super Stallions. The CH-53 is the U.S. Marine Corps' heavy lift helicopter, designed for the transportation of material and supplies. The aircraft can retrieve downed aircraft, including another CH-53. It is equipped with a refueling probe and can be refueled in flight, giving the helicopter indefinite range

[135] "V-22 Osprey," (17 December 2003 [cited 05 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/v-22.htm.

subject to aircrew limitations.[136] The CH-53X is assumed to be a CH-53E airframe with new 6,150 shaft horsepower engines, improved rotor system, and the associated airframe modifications, including the improved three-point lift system.[137] It is also assumed that the CH-53X will have the same fuel capacity and payload bay dimensions as the CH-53E. CH-53X characteristics:

- Cargo Area Dimension: 225 sq ft
- Weight Capacity: Internal load = 30,000 lbs; External load = 35,000 lbs
- Class I Cargo (food): 29,650 lbs of MREs
- Liquid Cargo Class III (fuel): 2,000 gals
- Class I (water): 3,240 gals
- Class V (artillery ammunition): 30,000 lbs
- Class V (small arms ammunition): 26,880 lbs
- Speed: 150 kts
- Range (loaded) = 480 NM; (empty) = 1,175 NM
- Troops (combat-loaded) = 24

Nine UH-1Y Iroquois. The UH-1Y is used for C2, medical evacuation, and to transport personnel, equipment and supplies. The primary mission of the UH-1Y in a Sea Base environment will be medical evacuation. The UH-1Y has a speed of 120 kts at sea level, a range of 170 NM, and can carry 12 troops. Configured as air ambulances, they can transport 3 litter patients and 4 ambulatory patients.[138]

5.8.4 Other Components

The MPF(F) has several embarked air assets that do not function as Connectors, but will have other Sea Base-related missions.

[136] "CH-53E Super Stallion," (09 March 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/ch-53e.htm.
[137] Nelms, Douglas W., "A Bigger, Better Giant," [online journal] (01 November 2003 [cited 26 September 2004]); available from the World Wide Web @ http://defensedaily.com.
[138] "UH-1 Iroquois (Huey)," (30 September 2004 [cited 02 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/uh-1.htm.

Eighteen AH-1Z Super Cobras. The AH-1Z is a two-seat, twin-engine attack helicopter capable of land and Sea Base operations. It provides close air support (CAS), armed escort, visual reconnaissance, and supporting arms coordination for the assault forces.[139]

Six Vertical Takeoff Unmanned Aerial Vehicles (VTUAV). The VTUAV's premier missions are reconnaissance, intelligence, surveillance, and target acquisition. They also provide substantial support to intelligence preparation of the battlefield, situation development, battle management, battle damage assessment, and even rear area security to monitor the operations security posture.[140]

Thirty-six F-35s. The F-35 JSF is a multirole fighter with in-flight refueling capability that is optimized for the air-to-ground role and is designed to meet the needs of the U.S. Air Force, U.S. Navy, U.S. Marine Corps and allies.[141] Its mission is to attack and destroy surface and air targets, and perform reconnaissance and armed escort missions.

In early 2004, the Air Force announced plans[142] to purchase some of the Short Takeoff/Vertical Landing (STOVL) versions of the F-35. Since no documentation could be found concerning deployment of these assets onboard the Sea Base, these assets are not considered. However, if deployed onboard the Sea Base they could be supported.

Ten SH-60Rs. The SH-60R Seahawk is a twin-engine helicopter. It can be used for anti-submarine warfare, search and rescue, drug interdiction, antiship warfare, cargo lift, and special operations. The SH-60R embarked on the MPF(F) will be used primarily in a plane guard status and will be equipped with a rescue hoist with a

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[139] "AH-1 Cobra," (30 September 2004 [cited 02 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/ah-1.htm.

[140] "Unmanned Aerial Vehicles UAVs," (02 August 2004 [cited 02 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/intell/systems/uav-intro.htm.

[141] "Joint Strike Fighter (JSF)," (11 March 2002 [cited 02 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/jsf.htm.

[142] Marc Selinger, "USAF to buy 'hundreds' of STOVL JSFs Gen. Jumper says," in Aerospace Daily & Defense Report, [online journal] (14 September 2004 [cited 13 October 2004]); available from the World Wide Web @ http://www.aviationnow.com/avnow/news/channel_aerospacedaily_story.jsp?id=news/jsf09144.xml.

250-ft (75 meter) cable that has a 600-lb (270 kgs) lift capability, and a retractable in-flight refueling probe.143 The SH-60R can carry 11 soldiers or 2,600 lbs (1,170 kgs) of cargo internally or a sling load of 9,000 lbs (4,050 kgs) of cargo externally.[144] It also performs combat search and rescue missions as required.

5.8.5 Sea Base Air Asset Distribution

In 2015, 1 CH-53X squadron contains 10 aircraft, 1 MV-22 squadron contains 12 aircraft, 1 UH-1Y squadron contains 9 aircraft, 1 AH-1Z squadron contains 9 aircraft, 1 SH-60R squadron contains 10 aircraft, and 1 F-35 squadron contains 12 aircraft. Complete aircraft squadrons are deployed onboard individual MPF(F) ships. During daily logistics operations, these air assets are redistributed as required, and return to their home ship at the end of operations. The specific aircraft are distributed on the 8 MPF(F) ships as listed below:

- MPF(F) 1: 1 MV-22 squadron of 12 aircraft and 1 AH-1Z squadron of 9 aircraft.
- MPF(F) 2: 1 MV-22 squadron of 12 aircraft and 6 VTUAVs.
- MPF(F) 3: 1 MV-22 squadron of 12 aircraft and 1 F-35 JSF squadron of 12 aircraft.
- MPF(F) 4: 1 MV-22 squadron of 12 aircraft and 1 SH-60R squadron of 10 aircraft.
- MPF(F) 5: 1 CH-53X squadron of 10 aircraft.
- MPF(F) 6: 1 CH-53X squadron of 10 aircraft.
- MPF(F) 7: 1 F-35 JSF squadron of 12 aircraft and 1 AH-1Z squadron of 9 aircraft.
- MPF(F) 8: 1 F-35 JSF squadron of 12 aircraft and 1 UH-1Y squadron of 9 aircraft.

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[143] “SH-60 Lamps Mark III Seahawk,” (08 November 2001 [cited 27 September 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/sh-60.htm.
[144] “SH-60 Lamps Mark III Seahawk,” (08 November 2001 [cited 27 September 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/sh-60.htm.

This aircraft distribution is developed because each squadron's manning and maintenance support equipment is not sufficient to support separate aircraft detachments onboard each individual MPF(F) ship. Table 5-4 shows the total deployed aircraft for the eight MPF(F) ships and the CH-46 equivalent parking space required for each type of aircraft.

Aircraft	Number of Aircraft	CH-46 Equivalent Space Required
MV-22	48	2.22
CH-53X	20	2.68
AH-1Z	18	0.92
UH-1Y	9	0.94
SH-60R	10	0.87
VTUAV	6	0.80
Total Rotary Wing Aircraft	**111**	**199**
STOVL F-35	36	2.05
Total Aircraft	**147**	**273**

Table 5-4: Total Deployed Aircraft.[145]

5.9 Transfers

Transfers are the systems that move troops, cargo and equipment between connectors or between connectors and the objective. Based on open literature and internal analysis, the SEA-6 Transfers functional team assesses the characteristics of the transfers to be as described below.

Cargo and equipment transfer capability onboard the selected MPF(F) ships is accomplished using several different applications. Two large, stabilized, sea state 3-capable cranes are incorporated into each MPF(F) ship to allow for skin-to-skin transfer[146] of heavy cargo loads and the onload and offload of LCACs.

Each MPF(F) ship is designed with an external Integrated Landing Platform (ILP) shown in Figure 5-3. The ILP allows an LCAC to land on and load vehicles via roll on/roll off (RORO) operations. Displacement craft such as the LCU(R) will moor to the end of the ILP and set their ramp down on the ILP to allow RORO operations.[147] The ILP is lowered to the sea surface and is held against the MPF(F) ship to prevent

[145] Souders et al., p. 21.
[146] Souders et al., p. 35.
[147] Souders et al., p. 21.

separation from the ship, but is free-floating and is allowed to move vertically with the action of the waves.[148]

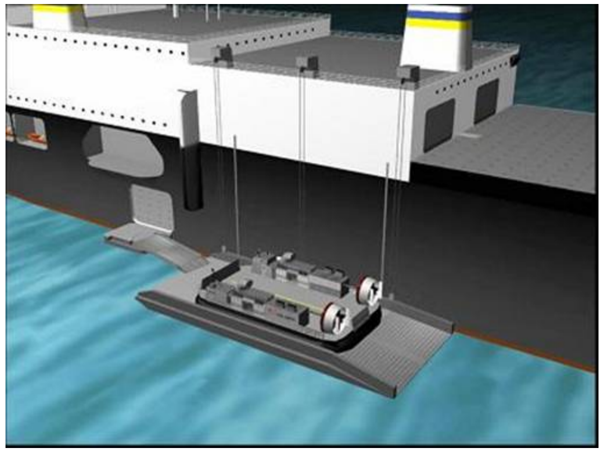

Figure 5-3: Integrated Landing Platform.[149]

To allow for the sending and/or receiving of both liquid and dry cargo, Standard Tensioned Replenishment Along-Side Method (STREAM) rigs with Heavy Underway Replenishment (Heavy UNREP) capability is utilized for the at-sea replenishment of the MPG ships as shown in Figures 5-4 and 5-5. Aircraft are refueled on board each MPF(F) ship utilizing current aircraft refueling practices. As mentioned above, each MPF(F) ship has sufficient flight deck space to accomplish two simultaneous VERTREPs.

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[148] Personal conversation with Guinevere Boyd of Naval Surface Warfare Center, Carderock Division (NSWCCD) on 20 October 2004.
[149] "Maritime Prepositioning Force, Future (MPF(F))," (18 October 2004 [cited 20 October 2004]); available from the World Wide Web @ http://peoships.crane.navy.mil/futureships/MPF(F)/MPF.htm.

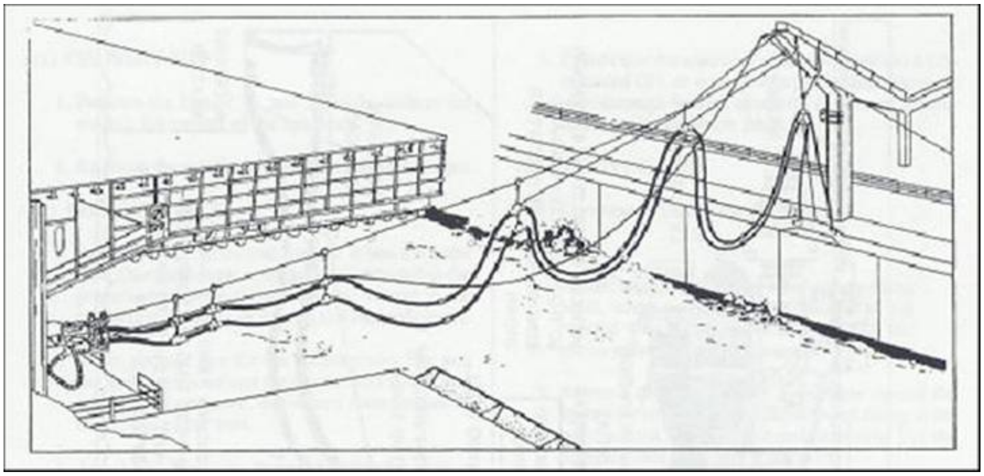

Figure 5-4: Fuel STREAM Rig.[150]

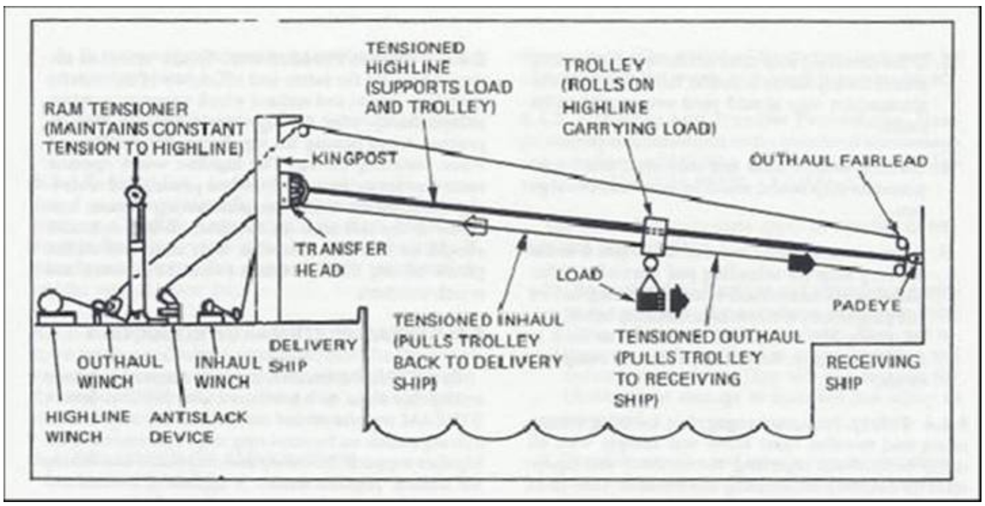

Figure 5-5: Cargo STREAM Rig.[151]

5.9.1 STREAM Transfer Rates

Each STREAM rig installed onboard the MPF(F) and CLF ships provides the capability of transferring, on average, approximately 2,600 bbls per hr (109,000 gals per hr) of diesel fuel, Marine (F-76), or approximately 3,000 bbls per hr (126,000 gals per hr) of JP-5 (F-44).[152] Additionally, for the transfer of dry cargo, the

[150] Naval Warfare Publication 4-01.4, Underway Replenishment Guide, March 2001, pp. 3-39.
[151] Ibid., pp. 3-39.
[152] Ibid., pp. 1-4.

proposed Heavy UNREP enhancement of the STREAM system allows for the transfer of cargo up to 12,000 lbs per lift, at a rate of approximately 210 tons per hr.[153]

5.9.2 MPF(F) Shipboard Crane System Capabilities

Each heavy lift crane system onboard the MPF(F) ships has a lift capacity of approximately 150 tons (300,000 lbs) allowing it to unload an LCAC weighing approximately 140 tons. Each LCAC is offloaded from the MPF(F) ship by the use of the heavy lift crane in sea states up to sea state 3. In sea state 4, the MPF(F) ship is held perpendicular to the prevailing seas to create a lee side that is locally at sea state 3.

5.9.3 Shipboard Aircraft Refueling

Each MPF(F) ship's flight deck can hot refuel five aircraft at once. The transfer rate of the aircraft refueling pumps is 125 gals per minute (7,500 gals per hr). Each CLF ship is equipped with one aircraft refueling station with a transfer rate of 125 gals per minute (7,500 gals per hr).

5.10 Command and Control

The joint publications do not specifically define logistics Command and Control (C2). However, Joint Publication 4-0 gives this summary for the Doctrine for Logistical Support of Joint Operations.[154]

> "Unity of command is essential to coordinate national and theater logistic operations. Logistics is a function of command. This principle is met through the combatant command's (COMCDRs) directive authority for logistics, which gives the COMCDRs authority to direct logistic actions and resources necessary to meet mission and operational tasking assigned to the command. To exercise control at the strategic, operational, and tactical levels of war, subordinate joint force and theater-level Service component commanders must also exercise control over their

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[153] Underway Replenishment Department Port Hueneme Division Naval Surface Warfare Center, "Expeditionary Maneuver Warfare Concepts for Resupply of Marine Corps Cargo to Sea-Based ARG/MPF Ships" (Port Hueneme, CA: January 2002), 4.

[154] "Doctrine for Logistic Support of Joint Operations," Joint Publication: 4-0, p. II-5, (06 April 2000 [cited 15 October 2004]); available from the World Wide Web @ http://www.dtic.mil/doctrine/jel/new_pubs/jp4_0.pdf.

respective logistic resources subject to the directive authority of the COMCDR."

5.10.1 Functional Overview

The logistics C2 system provides information to a decision maker in such a manner that knowledge can be gained, understood, and acted upon. This system relies on a robust communications network and user interfaces to provide asset visibility that predict consumption rates. Many commanders need to know the supply levels of the deployed force to plan the pace of future operations. The logistics C2 system's main purpose is to provide an accurate and quantifiable assessment of supply quantities and usage rates. From this assessment, operational commanders can evaluate real-time sustainment level and make real-time adjustments to prevent unintended operational pauses due to inadequate supply quantities. Figure 5-6 gives a skeletal structure for the logistics C2 system as developed by the C2 functional team.

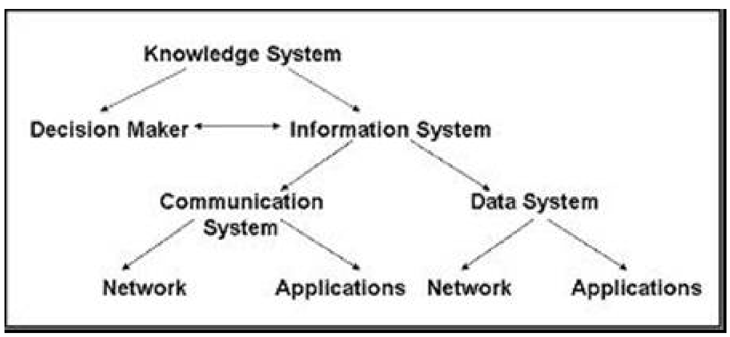

Figure 5-6: Taxonomy of the Logistics C2 System.

To exercise Command and Control of the logistics operations, the commander needs understanding, which is derived from data.

Item consumption is read from the operating units via passive means and transmitted to a central database (data). This central database will be either on the Sea Base or at the FLS. The raw data are manipulated by the system to obtain the desired variables needed to calculate a force sustainment level (information). The operational schedule is defined by discrete events. A combat force's operational plan lays out a ranked list of objectives. Despite the best planning, chance and the enemy influence the

planned schedule. The combat force adapts to accomplish the mission objectives. This also changes the amount of supplies needed. If logistic planning is based on combat events, the operational commanders are able to match supplies with operational events (knowledge).

Total asset visibility creates the avenue for real-time adjustment and delivery of the appropriate supplies to the combat force, thus alleviating the need for an operational pause for logistics (understanding). However, even with perfect asset visibility, the logistics system is only as good as the connectors that move the supplies. Connectors are discussed in more detail in Section 5.8 of this chapter.

The logistical system represents supply information in terms of a sustainment level as shown in Figure 5-8. The desired sustainment level is situational, but once defined by the commander, sustainment performance is easily calculated and reported.

$$\boxed{\text{Sustainment} = \frac{\text{Provisions (Supply)}}{\text{Consumption (Demand)}} \geq 1}$$

Figure 5-7: Calculating Sustainment.

5.10.2 Command Structure

The United States military has successfully conducted amphibious operations in the past. Traditionally, the command of the operation has been a function of where the amphibious troops are located. When the amphibious forces are aboard ship, they support the Maritime Component Commander and when the forces were en route to or ashore, they support the Ground Component Commander. SEA-6 assumes this same command structure is used in 2015. Figure 5-9 shows the command structure of Supporting and Supported Commanders (Commander, Sea Base (CSB) and Commander, Sea Base Maneuver Element (CSBME)) during each phase of the

expeditionary operation. During any phase of the operation, the Supported Commander controls the logistics.

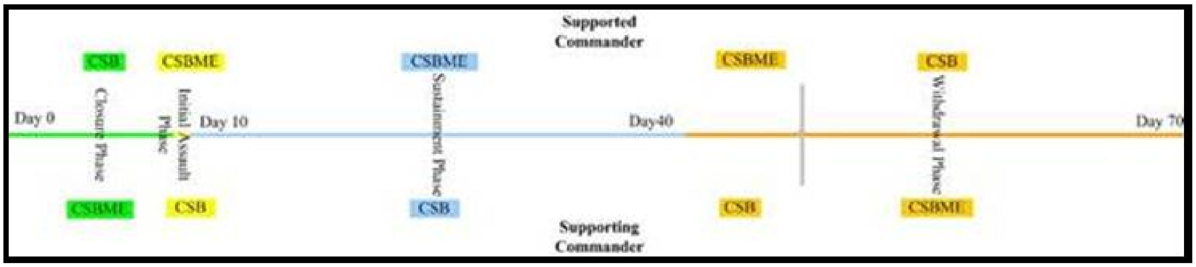

Figure 5-8: Supporting and Supported Commander over the 10/30/30 Timeline.

5.10.3 Control Structure

The system uses a Sense-and-Respond scheme to control the logistics flow. The information system is a combination of a communications system and a data system. The data system provides the total asset visibility and the communications system enables the action and feedback.

Sensing is performed by systems such as Radio Frequency Identification (RFID) tags, interrogators, and transmission units. These sensors supply data to the routable theater network. This routable network, the Global Information Grid (GIG), transfers the asset data to the processing applications. Information latency is an important performance driver of the system. Based on the Logistics Automatic Information Technology Concept of Operations, the time delay for intratheater shipments is 1-2 hrs.[155]

The data system receives the transmitted supply usage data from the operational units and manipulates it into the information required for the decision maker. The Joint Total Asset Visibility[156] program and the Global Command and Control System-Joint (GCCS-J) are currently working toward this solution. The supply usage data are fed into the Force Planning and Situational Awareness modules of GCCS-J.

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[155] Deputy Under Secretary of Defense (logistics), AIT Task Force, "Logistics Automatic Identification Technology Concept of Operations," November 1997.
[156] "JTAV Joint Total Asset Visability," (2001 [cited 10 October 2004]); available from the World Wide Web @ http://www.dla.mil/j-6/jtav/default.htm, 2004.

5.10.4 Supply Consumption Rate

The logistics community manages supplies using the 10 classes shown in Table 1-1. Classes I (food and water), III (fuel), and V (ammunition) supplies are focused on for this study.

If the logistics C2 loses asset visibility, supplies are shipped to the objective based on the planning factors listed in Table 5-5. These planning factors are from the Marine Air Ground Task Force (MAGTF) planning guide.[157]

Food (Class I)	Water (Class I)	Fuel (Class III)	Ammunition (Class V)	
Constant	Constant	Constant	Assault Phase	Sustain Phase
5.58 lbs/day/troop	7.00 gals/day/troop	134,388 gals/day	64.21 lbs/day/troop	3.88 lbs/day/troop

Table 5-5: Logistics Planning Factors.

5.11 Inventory and Storage

The JEB, its equipment, and 30 days' worth of food, fuel and ammunition is preloaded on the MPF(F) squadron of ships. The baseline MPF(F) ships have selective offload capability and other improvements to the current cargo inventory and storage system, such as RFID tags and automated inventory management systems, which utilize RFID supplied data via the logistics Automated Information System (AIS).[158]

Inventory and Storage consists of strike-up/strike-down, which includes storerooms, inventory management systems, and all equipment and space necessary to manage, store, repackage, and move cargo. Inventory and Storage includes assembly, assembly spaces, equipment storage spaces, ground vehicle and aircraft maintenance spaces, hangar spaces, medical facilities, and all other spaces and services required for a JEB.

Inventory and Storage in the 2015 period is improved from present systems through the use of RFID technology. Current policy states that RFID tags will be

[157] Marine Corps Combat Development Command, "MAGTF Planner's Reference Manual," April 2001, (United States Marine Corps MSTP Center (C 54) MCCDC, Quantico, VA, 20 April 2001), Part IV.
[158] The "Radio Frequency Identification (RFID) Policy" for the Department of Defense (DoD) was issued by the Under Secretary of Defense in July 2004. This policy outlines the criteria for active and passive RFID as well as Electronic Product Code ™ (EPC) tags.

interoperable throughout the DoD and that the Defense Logistics Agency (DLA) will manage active RFID tags.[159] This policy also establishes the rules for active and passive RFID tags, as well as the use of Electronic Product Code™ (EPC) data constructs. These rules include phase-in dates, frequencies, placement and interoperability.

Active RFID tags contain their own power source in the form of a battery and can both send and receive radio frequency signals. These tags will be used on both consolidated sustainment and retrograde shipment containers (i.e., 20- or 40-ft International Standards Organization (ISO) containers, engine containers, and air pallets). Active tags include information on both the container and its contents (through the use of nested visibility) and are updated whenever changes occur so that they accurately reflect the current container contents. Active RFID tags are required on prepositioned supplies and equipment.[160]

Passive RFID tags use the energy from the interrogating equipment to generate a response to queries; this means a much shorter range, approximately three meters,[161] but sufficient to provide nested visibility to active tags. Passive RFID tags will be used on case, pallet and item packaging (unit pack) for all unique identification (UID) items beginning in 2007. A graphic depiction of the RFID tagging system is shown in Figure 5-10.

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159 Ibid.
160 Ibid.
161 "Radio Frequency Identification (RFID) Tags," in Frontline [online journal] (2003 [cited 21 September 2004]); available from the World Wide Web @ http://www.frontlinetoday.com/frontline/article/articleDetail.jsp?id=114683.

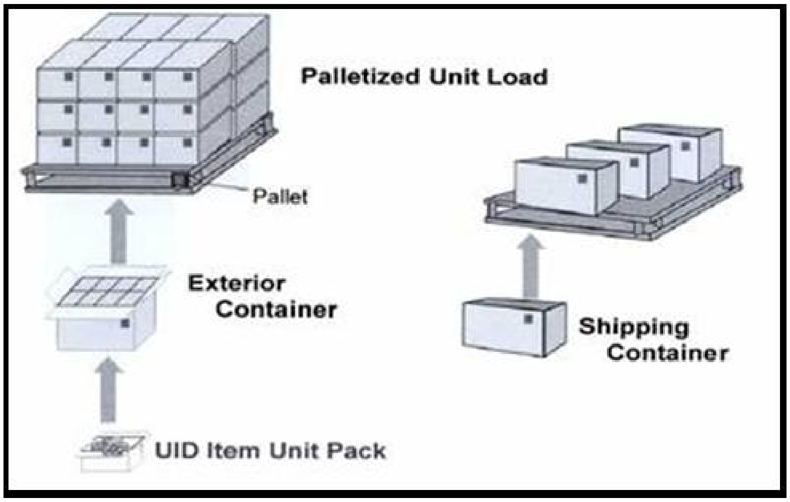

Figure 5-9: Graphic Depiction of RFID Tag Use.[162]

Packaging of supplies in the 2015 time frame is not changed from the way they are accomplished today. Although there are several ongoing studies concerning packaging, they do not meet the criteria of being a Program of Record. Cargo arrives at the Sea Base packaged in various containers and is broken down prior to storage, and repackaged prior to transport to the objective.

Fuel is packaged using different methods depending on the connector type used. Fuel is transported via air connectors in 500-gal fuel bladders or loaded onboard tanker trucks for transport by surface connectors. The CH-53X can carry up to 4 bladders[163] and the MV-22[164] up to 2. The LCAC[165] and LCU(R)[166] can carry fuel via 1,500-gal trucks only. The LCAC can carry up to four trucks and the LCU(R) up to 12.

[162] The "Radio Frequency Identification (RFID) Policy" for the Department of Defense (DoD) was issued by the Under Secretary of Defense in July 2004. This policy outlines the criteria for active and passive RFID as well as Electronic Product Code ™ (EPC) tags.
[163] "CH-53E Super Stallion," (09 March 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/ch-53e.htm.
[164] "NATOPS Flight Manual Navy Model MV-22B Tiltrotor," 01 June 2000, p. 9.5.
[165] "Landing Craft, Air Cushion (LCAC)," (17 July 2004 [cited 02 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ship/lcac.htm.
[166] "Landing Craft Utility (LCU)," (18 August 2004 [cited 02 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ship/lcu.htm.

5.11.1 Strike-up/Strike-down

Strike-up is the time it takes to break out, move cargo from a storeroom to a staging area, and prepare that cargo for transfer to a connector. This process begins when C2 receives a demand and ends when the transfer begins and the inventory system is updated to reflect the removal of the cargo from inventory. The ships' elevators, forklifts, pallet jacks, and other material handling equipment move the cargo. The process of strike-up is comprised of several steps in the logistics process onboard the MPF(F) ships. These steps occur sequentially, but contain delays while waiting in queues throughout the process. A simplified strike-up process flow is shown in Figure 5-11.

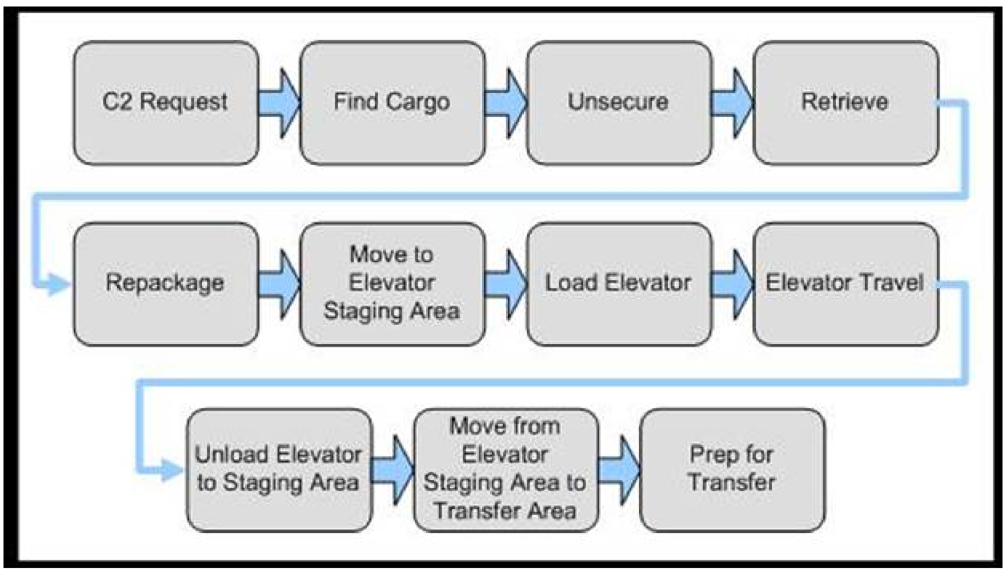

Figure 5-10: Strike-Up Flow Chart.

Each MPF(F) ship has three elevators and all elevators have access to all levels where storerooms are located. Elevators are assumed to be standard Navy elevators, rated for 10,500 lbs, that normally transport up to 3 standard pallets (3,000-lb, 54-sq in) or 2 loaded weapons skids (MHU-191M) per trip.[167] Eight 4,000-lb forklifts and 12 pallet jacks are also used for material handling.

[167] Naval Surface Warfare Center, Carderock Division (NSWCCD), "CVN Cargo Movement Process Study," November 2002.

Strike-down is the reverse process of strike-up. Strike-down is the time it takes to breakdown rigging and move cargo from the staging/receiving area to the storeroom, secure the cargo, and update the inventory management system with C2. Both the strike-up and strike-down process and inventory management must be capable of maintaining pace with the connector transfers. Inventory management is accomplished through use of RFID tags connected to the logistics AIS.

5.11.2 Assembly

Assembly is the time it takes to prepare vehicles for off-load to include preoperation checks, fueling, equipping, munitions loading, and matching troops with their equipment. Assembly requires a sufficient area to accommodate not only the assembly of the initial assault wave, but also an area where inoperable equipment can be set aside.

Each MPF(F) ship has 7,000 sq ft of assembly space allocated for each loading interface.[168] This assembly space is sufficient for one group of ready vehicles and two groups of vehicles in the process of being prepared for transfer.[169]

5.11.3 Aircraft Maintenance

Aircraft maintenance spaces accommodate Organizational Level (O-Level) and limited Intermediate Level (I-Level) repair. Depot Level repair is not conducted on board the MPF(F) unless a depot level team accompanies the ship or is sent to fulfill a specific request. Each squadron has their own O-Level workspaces to support their aircraft.

A CNA study170 recommended that 50,000 sq ft of space would be required for maintenance, but did not specify if this was O-Level, I-Level, or both. Each MPF(F) has a total of 50,000 sq ft of maintenance space. The 50,000 sq ft of maintenance space is used for both ground vehicle and aviation maintenance.

[168] Souders et al., p. 20.
[169] Ibid., p. 17.
[170] Ibid.

The O-Level spaces include electronics/electrical, airframes/hydraulic, power plant, aircrew flight gear, line, ordnance, quality assurance, and maintenance control workspaces. Many of these spaces are shared between like squadrons. Additionally, a ready room and various administrative spaces are provided for the squadrons.

The I-Level maintenance is conducted by an Intermediate Maintenance Activity (IMA) and is limited in nature. Based on the fleet experience of various SEA-6 team members, much of the avionics will need to be Organizational to Depot (O to D) Level repair as the expense, extensive maintenance, and calibration of avionics benches are prohibitive to the MPF(F) system. Additionally, the maintenance required to provide operational and calibrated avionics benches (after long periods in storage) cannot be accomplished within the 10-day requirement. A smooth supply system is needed to support the O to D repair needs of the Air Combat Element. The current Mobile Facility system (maintenance vans) can be used to meet the needs for an IMA onboard the MPF(F) ships; however, the maintenance vans cannot be shipped and installed onboard the MPF(F) ships within 10 days. If located on the MPF(F), these vans will still require the same maintenance and calibration needed for regular shops. The I-Level spaces are listed below:

IM 1 - Maintenance/Materiel/Admin/Quality Assurance (QA) Division

- Production Control
- QA
- Maintenance Admin
- Aeronautical Material Screening Unit (AMSU)

IM 2 - General Maintenance Division

- Power Plants (limited to engine build-up)
- Tire/Wheel and Brakes
- Hydraulics (Hose and Tube)
- Non-Destructive Inspection (NDI)
- Airframes (includes Welding)

- Paraloft
- Aircrew Survival Systems (oxygen and ejection seats)
- Other Administrative Spaces

IM 3 - Avionics/Armament Division

- Battery
- Mini/Micro Repair (soldering)
- Radio Repair (utilizing suitcase test sets provided by embarked squadrons in a fully operational and calibrated status)
- Controlled Material Security (CMS) Vault
- Ordnance Repair (bomb racks/rails)
- Other Administrative Spaces

IM 4 - Support Equipment (SE) Maintenance Division

- Hydraulics
- Electrical
- Tire/wheel
- General Vehicle Repair
- Corrosion and Painting
- Preventative Maintenance
- SE training and licensing
- Other Administrative Spaces

SEA-6 assumes that the IMA SE Division is expanded to accommodate vehicle repair required for assembly and reconstitution of the ground vehicles used at the objective. The use of this division requires special consideration in the Naval Aviation Maintenance Program (NAMP)[171] to accommodate the unique nature of this dual use. The duplication of repair equipment and space for vehicle maintenance may be cost

[171] Department of the Navy, Office of the Chief of Naval Operations, "OPNAV INSTRUCTION 4790.15D, Naval Aviation Maintenance Program (NAMP)," 26 June 2002.

prohibitive and unnecessary, unless vehicle maintenance is combined with IMA SE spaces.

5.11.4 Ground Vehicle Maintenance

Ground vehicle maintenance space is required to repair vehicles found faulty during the assembly phase and all vehicles brought back to the ship for repair during the sustainment and the reconstitution phase. Vehicle maintenance spaces will be largely the same as those required for the IMA SE spaces, only magnified to accommodate the increased vehicle size and number. The IMA SE spaces could be used in conjunction with aircraft support equipment if needed or desired as stated above.

As mentioned in Section 5.11.3, the space required for ground vehicle maintenance would be approximately 50,000 sq ft. The chosen MPF(F) design allows a total of 50,000 sq ft of maintenance space, which was assumed to be a combination of both ground vehicle and aviation maintenance. The spaces would also require special equipment (heavy lift jacks and maintenance stands) to accommodate maintenance on large equipment such as the M1A1 tank. The Ground Vehicle Maintenance spaces needed include:

- Hydraulics
- Electrical
- Tire/Wheel
- General Vehicle Repair
- Corrosion and Painting
- Preventative Maintenance
- Air-conditioning Servicing
- Ordnance Repair

5.11.5 Aircraft Hangar Space

Hangar bays require sufficient space to park approximately 25% of the embarked aircraft. It is assumed that one aircraft elevator is available to move aircraft between the

hangar bay and the flight deck. This elevator is large enough to accommodate two aircraft simultaneously. The elevator may also be used to move cargo from the flight deck to the hangar deck during VERTREP evolutions.

The minimum required hangar bay space is 8,750 sq ft to accommodate 25% of the ACE aircraft. The recommended hangar bay space is increased to 10,000 sq ft to facilitate maneuvering and maintenance.

5.11.6 Medical

Medical spaces are able to accommodate the casualties expected for each MPF(F) ship's share of the ground forces utilized during a beach assault or other heavy combat. The chosen MPF(F) ship includes 5,000 sq ft of medical space for a total of 40,000 sq ft per MPG.

Based on a recent CNA study[172] (centered on 6-8 MPF(F) ships) it is recommended that each ship have 6,500 sq ft of medical space to include 90 beds and the capacity to handle approximately 40 casualties per day. The medical requirements for each ship are:

- Dental
- Pharmacy
- X-ray
- Lab
- Blood storage
- Operating Rooms
- Acute Care Room/Beds
- Overflow Area/Beds
- Screening/Waiting Area
- Other Administrative Areas

[172] Souders et al.

5.12 Eliminated Platforms

This section summarizes the platform designs that were not selected for the 2015 BLA. Platforms eliminated from the 2015 BLA composition include High Speed Vessels (HSVs), CH-46 helicopters and Amphibious Command Ships (LCCs). The HSV is eliminated from this study because it does not meet the criteria of being a Program of Record. The CH-46 is eliminated because it is being phased out and will not be available for operational use in 2015. LCCs are eliminated as C2 is incorporated into the chosen MPF(F) ship. Preliminary analysis, reinforced by a recent CNA study, identified the need for replenishment at sea for the MPF(F) ships. Of the current Combat Logistics Force (CLF) ship classes, the T-AKE class is eliminated from consideration because the fuel capacity of 18,000 bbls is insufficient to fulfill the refueling requirements of the Sea Base.

5.13 2015 Baseline Architecture Views

Architecture defines "the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time."[173] The architecture views selected reflect the Department of Defense Architecture Framework (DODAF).[174] DODAF is chosen because it is the current format used within the DoD. It provides a common approach for description development, presentation, and integration of DoD architectures to assist in the ease of understanding across organizational boundaries.

Architecture views describe attributes and relationships within the architecture. The three prominent views—Operational View (OV), Systems View (SV), and Technical Standards View (TV)—and their relationships are shown in Figure 5-12. The OV describes, "The tasks and activities, operational elements, and information exchanges required to accomplish DoD missions."[175] The SV "describes systems and

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[173] "Glossary of Terms/Acronyms," (02 August 2004 [cited 08 September 2004]); available from World Wide Web @ http://www.army.mil/aeioo/toolkits/glossary.html.
[174] DoD Architecture Framework Working Group, "DoD Architecture Framework (DODAF)[174] Version 1.0, Vol. I: Definitions and Guidelines," 15 August 2003.
[175] Ibid., pp. 1-2.

interconnections providing for, or supporting, DoD functions" and "associated systems resources to the OV."[176] The TV is "the minimal set of rules governing the arrangement, interaction and interdependence of system parts or elements."[177] The final views defined by the DODAF are the All-Views (AV). The AV provides general information applicable to the entire architecture. AVs are not specific diagrams, but are descriptions of the overall scope.

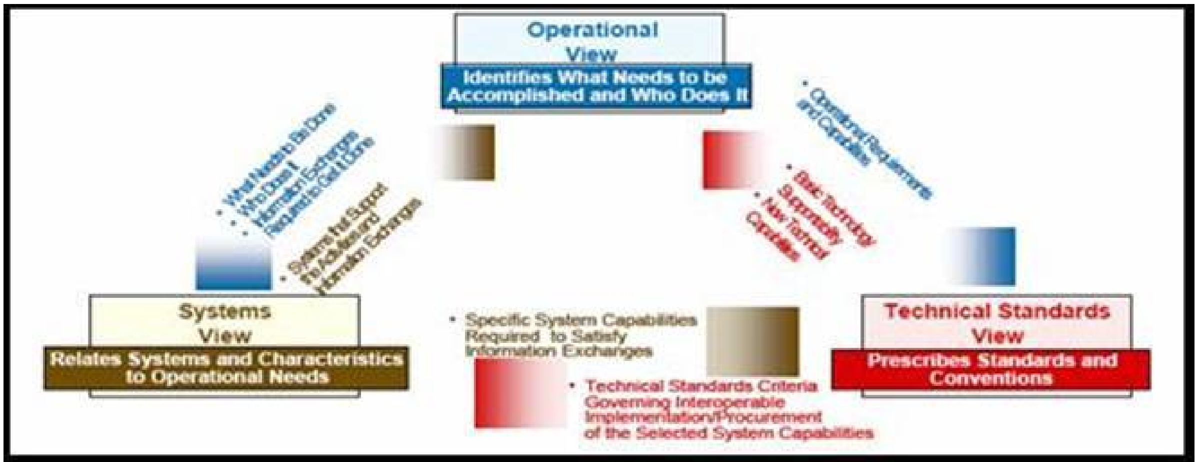

Figure 5-11: Architecture View Relationships.[178]

The Joint Capabilities Integration and Development System (JCIDS)[179] recommends the following products be developed for any new **D**octrine, **O**rganization, **T**raining, **M**ateriel, **L**eadership and education, **P**ersonnel and **F**acilities (DOTMLPF) solution:

- OV-1: High-Level Operational Concept Graphic
- OV-2: Operational Node Connectivity Description
- OV-3: Operational Information Exchange Matrix
- OV-5: Operational Activity Model
- OV-6c: Operational Event-Trace Description

[176] Ibid., pp. 1-2.
[177] Ibid., pp. 1-3.
[178] Ibid., p. ES-1.
[179] "Operation of the Joint Capabilities Integration and Development System," in Chairman of the Joint Chiefs of Staff Manual (CJCSM) 3170.01, (12 March 2004 [cited 08 September 2004]); available from the World Wide Web @ http://www.dtic.mil/cjcs_directives/cdata/unlimit/m317001.pdf.

- SV-1: System Interface Description
- SV-2: Systems Communications Description (for communications networks)
- SV-6: Systems Data Exchange Matrix
- TV-1: Technical Standards Profile

The DODAF recommends the following additional products:

- AV-1: Overview and Summary Information
- AV-2: Integrated Dictionary

Of these, SEA-6 uses the following architecture views:

- OV-1: 2015 Baseline Architecture Operational Concept Graphic
- OV-2: 2015 Baseline Architecture Operational Node Connectivity Description
- SV-1: 2015 Baseline Architecture Systems Interface Description

5.13.1 Operational View

Figure 5-13 shows the 2015 BLA Operational Concept Graphic (OV-1). This view depicts SEA-6's graphic representation of the architecture. The FLS shown in the distance at left represents the starting point for the MPG. The MPG is depicted as MPF(F) ships, which carry the JEB from the FLS to the Sea Base, a resupply ship used to resupply the MPF(F) ships, and a LCU(R) ship, which assists in the initial movement of troops and equipment to the beach. The LCAC and aircraft represent the connectors providing logistical support between the MPG and objective. The lightening bolts represent the C2 system linking all assets together. The single CSG in the right background represents the inclusion of CSGs and ESGs in the Sea Base.

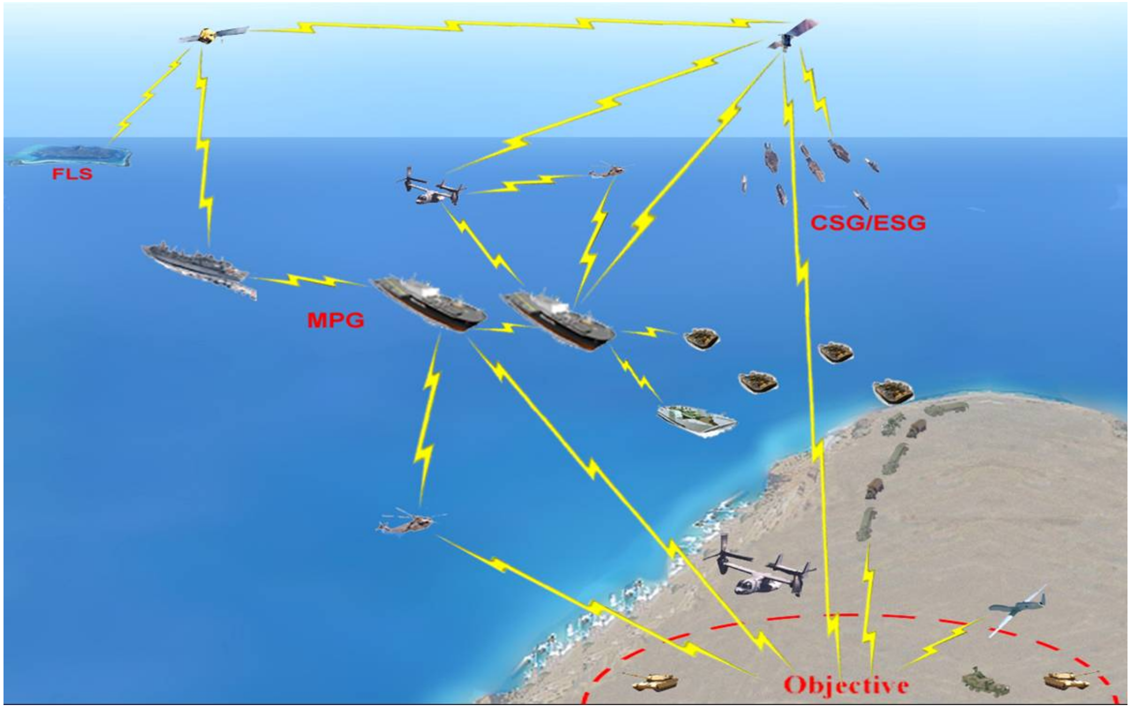

Figure 5-12: OV-1 2015 Baseline Architecture Operational Concept.

The 2015 Baseline Architecture Operational Node Connectivity (OV-2) is shown in Enclosure 4 (OV-2 2015 Baseline Architecture Operational Node Connectivity). This graphic shows operational nodes with information exchange needlines. The operational node is an information source and/or sink and may be external or internal to the 2015 BLA. Operational node types include, but are not limited to roles and logical/functional types such as connectors and organizations.

Needlines represent the requirement to exchange information between operational nodes. Annotated on the needlines are the primary types of information required. The arrows indicate the direction of information flow.

5.13.2 Systems Views (SV)

The 2015 Systems Interface Description (SV-1) is shown in Figure 5-14. This diagram shows the system nodes[180] with the system function listed inside the node

[180] System nodes are defined in the Department of Defense Architecture Framework (DODAF) as nodes with the identification and allocation of resources (e.g., platforms, units, facilities, and locations) required to implement specific roles and missions.

symbol. The lines connecting the nodes are the system interfaces between the nodes. Several of the interface lines are denoted as "key interfaces." For this architecture, key interfaces are considered mission critical. In order to achieve C2 functions or to provide total asset visibility, these key interfaces must be maintained. Additionally, since the nodes do not necessarily represent platforms from the same service, interoperability is a critical system attribute to allow the information exchange across these interfaces.

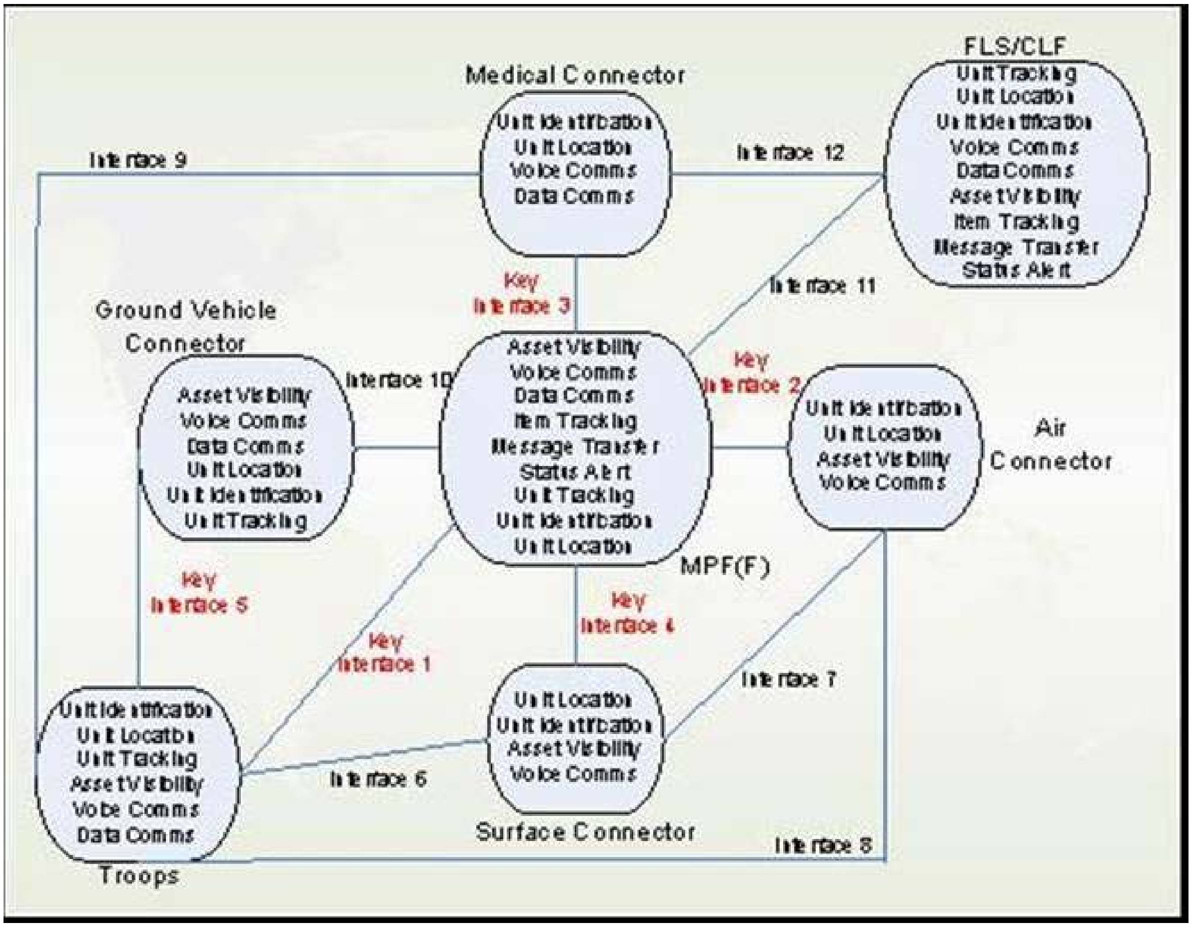

Figure 5-13: SV-1 2015 Baseline Architecture Systems Interface Description.

5.14 2015 Baseline Architecture Concept of Operations

As described in Chapter 3, within 10 days of the deployment order, the Combined Task Force Commander (CTF CDR) deploys the 3 BLTs to seize the initiative. These forces deploy to the initial objective within one period of darkness. Using the

deployment order receipt as a starting point, this section describes a possible concept of operations for the 2015 BLA.

5.15 Closure Phase

5.15.1 Deployment and Transit

Upon receipt of the deployment order, the personnel and aircraft that deploy aboard the MPF(F) ships begin moving to the FLS. If not already in port, two of the MPF(F) ships will dock at the FLS pier and all other MPF(F) ships will rendezvous at the FLS anchorage site.

Movement of JEB personnel from their base of origin to the designated FLS is accomplished by the use of the Civil Reserve Air Fleet (CRAF).[181] "The Civil Reserve Air Fleet is made up of US civil air carriers who are committed by contract to providing operating and support personnel for DoD. The CRAF program is designed to quickly mobilize the nation's airlift resources to meet DoD force projection requirements."[182] Table 5-6 shows CRAF aircraft types with their approximate passenger capacities.

Aircraft	Number of Passengers
Boeing B747	364
Douglas DC-10	242
Lockheed L-1011	246-340

Table 5-6: CRAF aircraft types and passenger numbers.[183]

Personnel are expected to begin boarding the aircraft within 24 hrs of receipt of the deployment order. Aircraft begin transiting to the FLS upon completion of personnel boarding.

Air assets are not based at the FLS and require either self-deployment or transport by means of surface or air. The MV-22 and F-35 aircraft self-deploy and fly either

[181] "Civil Reserve Air Fleet," (18 November 2001 [cited 18 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/craf.htm.
[182] Ibid.
[183] Ibid.

directly to the MPF(F) ships or to the FLS. MV-22s have an unrefueled ferry range of 1,100 NM and the F-35's unrefueled ferry range is estimated to be approximately 1,200 NM based on a combat range of 600 NM.[184] Transit distances and flight times are calculated from various flight points of origin to each of the FLS locations and are detailed in Enclosure 3 (Transit Time Analysis).

Although SEA-6 assumes that these air assets are deployed from the closest forward base, the worst-case scenario, deployment from the Continental U.S. (CONUS), is also considered. Tanker support for inflight refueling of the MV-22 and F-35 aircraft is required on most of the trip legs from the CONUS to Guam or Diego Garcia. Although not every leg requires tanker refueling, it is desirable to have tankers escort the aircraft the entire way. Likewise, the trip from the East Coast to Sigonella does not require tanker support, but should be provided if tankers are available. If tanking is not available for the Sigonella trip, the aircraft are required to make numerous refueling stops, increasing the flight times and the risk of breakdowns. If aircraft do break down while enroute, rescue missions are required.

For the large number of MV-22 and F-35 aircraft required, squadrons will most likely deploy from several locations over the course of several days. Additionally, the launching of such a large number of aircraft requires that they be launched in waves so as not to overwhelm the tanking support and the support structure of the refueling and remain over night (RON) locations.

Although the CH-53X has in-flight refueling capability, it is limited to approximately 8 hrs due to pilot fatigue[185] and therefore is transported to the FLS. One method of transport is onboard an aircraft carrier that transits directly to the FLS or Sea Base. While this method of transport has several advantages, it also relies on a

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[184] "F-35 Joint Strike Fighter Specifications," (08 November 2001 [cited 18 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/jsf-specs.htm.

[185] Captain Daniel Stimpson, USMC, <dstimpso@nps.edu>, "RE: CH-53 Transport Times," 02 November 2004, office communication (02 November 2004). Captain J. Mark Lozano, USMC, <jmlozano@nps.edu>, "RE: CH-53 Transport Times," 02 November 2004, office communication (02 November 2004). CAPT Thomas H. Hoivik, USN (Ret), <thhoivik@nps.edu>, "RE: SEA-6 project question," 02 November 2004, office communication (02 November 2004).

carrier being available and prevents that carrier from being utilized in its primary role. Travel time leaving from San Diego takes approximately 7 1/2 days to Guam, almost 14 days to Diego Garcia, and 6 days to reach Sigonella from Norfolk.

Considering the 10/30/30 time constraint, the quickest transport method is to load the helicopters onboard C-5 or C-17 aircraft and fly them to the FLS. Only 2 CH-53Xs can fit in a C-5 and only 1 in a C-17. Maintenance personnel, tools, parts, and support equipment could also be loaded onboard the transport aircraft for immediate use upon arrival. The C-17 has a range of 5,200 NM at 450 kts. The C-5 has virtually the same range and speed as the C-17. Enclosure 3 shows travel times and routes to the FLS for both C-5 and C-17 aircraft.

The CH-53X requires considerable preparation prior to loading into a C-5 or C-17. SEA-6 contacted several CH-53X pilots to obtain information concerning this evolution[186] reflected in the following discussion of CH-53X preparation for transport and restoration following transport.

The entire main gearbox, rotor head, and tail pylon is removed and the tires are replaced with smaller tires to allow clearance into the aircraft. If maintenance personnel work around the clock, one CH-53X can be prepared for loading in approximately 18 hrs. Since it requires 18 hrs of maintenance per aircraft, and each squadron has 10 aircraft, and the squadrons can work on 3 aircraft simultaneously, this requires four 18-hr periods totaling approximately 3 days.

Once at the FLS, each CH-53X aircraft requires approximately 1 day to reassemble, perform vibration analysis and complete a Functional Check Flight (FCF). Again, each squadron can work on 3 aircraft simultaneously. With 10 aircraft to complete per squadron, each squadron requires approximately 4 days to complete all 10 aircraft. This optimistically assumes all maintenance actions go as planned. Although

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[186] Major Mike Carter, USMC, <macarter@nps.edu>, "RE: CH-53 pilot question," 02 November 2004, office communication (02 November 2004). Captain Daniel Stimpson, USMC, <dstimpso@nps.edu>, "RE: CH-53 Transport Times," 01 November 2004, office communication (02 November 2004). Captain J. Mark Lozano, USMC, <jmlozano@nps.edu>, "RE: CH-53 Transport Times," 01 November 2004, office communication (02 November 2004).

the plan is to complete the maintenance and FCF on the aircraft prior to getting underway, ultimately, any helicopters not completed will need to be craned onboard the MPF(F) ships and completed en route.

The UH-1, AH-1, and the SH-60 aircraft do not require disassembly prior to transport or reassembly at the FLS. Eight AH-1Zs, 6 UH-1Ys, or 6 SH-60Rs can fit into a C-5. Four UH-1Ys, 4 AH-1Zs, or 4 SH-60Rs can fit in a C-17. Once at the FLS, these helicopters are quickly prepared for operations prior to flying aboard the MPF(F) ships.

5.15.2 Assembly

Each MPF(F) ship is already loaded with the prepositioned equipment, minus aircraft and LCACs. The LCACs are located at the FLS and are craned onboard the MPF(F) ships while the troops are loading. Helicopters arrive at the FLS as discussed in the previous sections and are flown aboard the MPF(F) ships once maintenance preparations are complete. MV-22 and F-35 aircraft rendezvous with their MPF(F) ship if at sea or at the FLS if their ship is in port.

Upon arrival at the FLS, personnel debark the airlifts and are transported to the pier where two MPF(F) ships are docked. Personnel distribution and load out plans are prearranged so all personnel are located on the same MPF(F) ship as their equipment. Once personnel boarding is complete, each ship transits to the anchorage area to await the arrival of its designated aircraft. After the first MPF(F) ship boards all personnel and clears the pier, the next MPF(F) ship will take its place. This process will continue until all MPF(F) ships are loaded.

Once personnel boarding is complete, the ground vehicle maintenance personnel will begin preparing the vehicles for use. This preparation takes place in the vehicle storage spaces, and takes an average of four days.[187]

The assembly process begins and must be completed prior to the initial movement of personnel and equipment from the Sea Base to the objective. The LCACs are

[187] Major Robert E. Cote, USMC, <CoteRE@bic.usmc.mil>, "RE: MPF(F) studies at NPS," 04 October 2004, office communication (19 October 2004).

offloaded and the initial wave of eight LCACs is prestaged on the Integrated Landing Platforms (ILP). Ammunition, food, and water is brought up from the MPF(F) ship storerooms and prestaged in the assembly areas. Approximately 12 hrs prior to offload, ground vehicles begin moving to the assembly areas, where the loading of ammunition, food, equipment, and water occurs.

5.15.3 Sea Base Formation

The MPF(F) ships that are transporting F-35 or MV-22 aircraft will begin transit to the JOA upon completion of their personnel boarding, but no more than one day prior to aircraft arrival at the FLS. The MPF(F) ships designated as home ships for the helicopter squadrons remain at anchorage until all their helicopters have successfully completed required checks and are ready to begin fly-on as discussed in Section 5.15.1. Once each MPF(F) ship has embarked its helicopters, the ship begins transit to the Sea Base. The T-AOE and LCU(R) are either at the FLS, or underway near the FLS. They begin transit to the Sea Base along with the first MPF(F) ships.

Just prior to conducting the first wave of troop and equipment movement to the objective, the MV-22s and CH-53Xs redistribute from their home ships to the other MPF(F) ships. Once this redistribution is complete, the movement of troops and equipment from the Sea Base to the objective commences.

5.16 Employment Phase

The troops transported from the Sea Base to the objective during one period of darkness are described in Section 5.3.1 of this chapter. The MV-22 aircraft transports these personnel. Each MV-22 is capable of transporting 24 combat troops, along with their personal equipment, directly to the objective. Personnel required to operate the equipment being transported on the LCU(R)s and LCACs are transported, along with their equipment to the ashore location.

Equipment is transported from the Sea Base by the use of air and surface connectors. The equipment required to be transported ashore during the first period of darkness is discussed in Section 5.3.1 of this chapter. The equipment designated for

air transport is moved by the CH-53Xs and is specified in Enclosure 1B, landing priorities 1-8. The equipment designated for surface transport is moved by the LCU(R)s and by the LCACs and is specified in Enclosure 1A, landing priorities 1-19. The equipment moved by air connectors is taken directly to the objective and the equipment moved by surface connectors is offloaded at the beach and moved under its own power to the objective.

The remainder of equipment not specified in the previous paragraph is transported from the Sea Base in the same manner described above. This equipment is detailed in Enclosure 1A, landing priorities 20-28 and Enclosure 1B, landing priorities 9 and 10 and is transported immediately following the initial equipment movement.

5.17 Sustainment Phase

At the objective, ammunition is carried by the use of heavy tactical wheeled vehicles (i.e., MK48 Logistics Vehicle System (LVS)) and medium tactical vehicles (i.e., XM1091 Fuel/Water Tanker) carry fuel with a 1,500-gal capacity. Two days' worth of food and water are carried by the individual troop vehicles listed in Enclosures 1A and 1B. The total capacity of the ammunition carriers is 3 days' worth of ammunition and the total capacity of fuel carriers is 2 1/2 days' worth of fuel.

The MV-22s and CH-53Xs resupply the forces at the objective. Supplies delivered by these connectors are brought directly to the forces at the objective. Once all cargo is offloaded, the connectors return to the Sea Base, where they reload. Supply priorities are established by sense and respond logistics. An on-hand ratio is calculated by dividing current on-hand quantity of a particular type (fuel, water, food, or ammunition) by the carrier vehicle capacity. The lowest ratio calculated becomes the highest priority for resupply.

5.18 Medical Evacuation

In the event that medical evacuation of combat forces becomes necessary, the closest UH-1, MV-22, or CH-53X is diverted. If no connector is airborne, one is launched from the Sea Base, transits directly to the location of the injured personnel, load

the injured personnel according to the capacities detailed in Section 5.11.6 of this chapter. Patients are returned to the Sea Base, where they receive medical attention.

Enclosure 1A: Sea Base Maneuver Element (SBME) Equipment Breakdown (Surface BLT)

NOTE: UNITS LISTED ARE PER SURFACE BATTALION LANDING TEAM (BLT). THE SBME CONTAINS TWO SURFACE BLTs. TOTAL WEIGHTS AND AREAS APPEAR IN RED TEXT BELOW.

Landing Priority	Unit	# Personnel	Equipment Type	Equipment Quantity	Indiv Weight (lbs)	Total Weight (lbs)	Indiv Area (ft^2)	Total Area (ft^2)
1	Rifle Co 1 (Reinforcement) AA Plt	233	EFV-P	12	72,879	874,548	360.0	4320.0
2	Tank Plt 1	8	M1A1	2	133,815	267,630	387.0	774.0
		8	M1A1 w/TWMP	2	141,075	282,150	506.8	1013.6
3	Rifle Co 2 (Reinforcement) AA Plt	233	EFV-P	12	72,879	874,548	360.0	4320.0
4	Tank Plt 2	8	M1A1	2	133,815	267,630	387.0	774.0
		8	M1A1 w/TWMP	2	141,075	282,150	506.8	1013.6
5	A Command	143	EFV-P	10	71,344	713,440	360.0	3600.0
	AA Plt	8	EFV-C	1	66,351	66,351	360.0	360.0
6	Rifle Co 3 (Reinforcement) AA PLT	233	EFV-P	12	72,879	874,548	360.0	4320.0
7	Tank Plt 3	16	M1A1	4	133,815	535,260	387.0	1548.0
8	Tank Co Hq	8	ABV	2	1,350	2,700	468.0	936.0
	Det, CEB Co	4	AVLB	1	93,194	93,194	468.0	468.0
	Det, Engr Spt Plt	8	M1A1	2	133,815	267,630	387.0	774.0
	ABV and ACE	5	M88A2	1	141,173	141,173	340.5	340.5
	Det, AT Plt, Tank Bn	4	M9 ACE	4	37,799	151,197	215.3	861.0
		8	M998 HMMWV w/M101Trailer	2	12,118	24,236	185.3	370.7
		3	M998 HMMWV w/M116 Trailer	1	12,778	12,778	196.1	196.1
		3	MRC JTRS HMMWV	2	8,720	17,440	64.8	129.7
		4	M1043 HMMWV	1	10,158	10,158	109.8	109.8
		18	M1045 HMMWV	6	9,918	59,508	109.2	655.2
		9	M998 HMMWV	3	8,918	26,754	109.3	327.9
9	CAAT Plt	24	ITV	8				
	Scout Snipers	40	M1043 HMMWV	10	10,158	101,580	109.8	1,097.9

Landing Priority	Unit	# Personnel	Equipment Type	Equipment Quantity	Indiv Weight (lbs)	Total Weight (lbs)	Indiv Area (ft^2)	Total Area (ft^2)
	TACP	32	M1045 HMMWV	8	10,218	81,744	109.2	873.6
		9	M998 HMMWV	3	8,918	26,754	109.3	327.9
		2	MRC JTRS HMMWV w/M101 Trlr	1	11,770	11,770	140.9	140.9
10	B Command	18	EFV-P	1	72,454	72,454	360.0	360.0
	Det, AA Plt	12	EFV-C	1	67,551	67,551	360.0	360.0
	Arty Bn LNO Tm	4	M998 HMMWV w/M101 Trlr	1	12,118	12,118	185.3	185.3
	NGLO Team	9	MRC JTRS HMMWV	3	9,170	27,510	64.8	194.5
11	LAR Co B	84	LAV 25	14	28,685	401,590	173.3	2,425.5
		4	LAV AT	4	30,624	122,496	171.5	686.0
		6	LAV C2	1	29,121	29,121	174.6	174.6
		2	LAV L	3	29,429	88,287	173.5	520.6
		3	LAV M	2	30,047	60,094	172.2	344.4
		6	LAV R	1	31,103	31,103	200.0	200.0
12	A Command Veh/Pers	8	M1043 HMMWV	2	10,158	20,316	109.8	219.6
		12	M998 HMMWV	3	9,218	27,654	109.3	327.9
		12	MRC JTRS HMMWV	4	10,670	42,680	64.8	259.4
		4	MRC JTRS HMMWVw/M101 Trlr	1	10,870	10,870	140.9	140.9
13	Det Arty Btry C (3 Guns)	3	M1043 HMMWV	1	9,858	9,858	109.8	109.8
		12	M998 HMMWV w/M101 Trlr	3	12,118	36,354	185.3	556.0
		24	MTVR w/LW155	3	46,208	138,624	214.4	643.1
		9	MTVR w/M105 Trlr	3	53,068	159,204	310.6	931.9
		6	MRC JTRS HMMWV	2	9,170	18,340	64.8	129.7
14	Avenger Section	10	Avenger	5	13,613	68,065	116.5	582.3
		3	MRC JTRS HMMWV	1	9,170	9,170	64.8	64.8
15	Arty Btry C (-) (3 Guns)	4	M1043 HMMWV	1	10,158	10,158	109.8	109.8
	Det, CBR Plt, HQ Btry	4	M998 HMMWV w/M101 Trlr	1	12,118	12,118	185.3	185.3
		3	MRC JTRS HMMWV	1	9,170	9,170	64.8	64.8
		4	MTVR	1	45,008	45,008	214.4	214.4
		24	MTVR w/LW155	3	46,208	138,624	214.4	643.1
		15	MTVR w/M105 Trlr	5	53,068	265,340	310.6	1,553.1

Landing Priority	Unit	# Personnel	Equipment Type	Equipment Quantity	Indiv Weight (lbs)	Total Weight (lbs)	Indiv Area (ft^2)	Total Area (ft^2)
		3	MTVR w/M149 WB	1	50,308	50,308	307.8	307.8
		2	4K Forklift	2	12,004	24,008	106.2	212.3
		4	M1035 HMMWV	1	8,890	8,890	106.3	106.3
		12	AN/TPQ (4 HMMWV & 4 Trlr)	1	53,476	53,476	108.5	108.5
16	Det CEB Co B	6	MTVR Dump truck w/MK155	3	52,541	157,623	339.0	1,017.1
		3	M998 HMMWV	1	8,918	8,918	109.3	109.3
17	B Command (Veh/Pers)	18	M998 HMMWV	6	8,918	53,508	109.3	655.7
		9	M998 HMMWV w/M101 Trlr	3	11,818	35,454	185.3	556.0
		6	MRC JTRS HMMWV	2	9,170	18,340	64.8	129.7
18	Inf Bn Combat Trains	6	M1035 HMMWV	2	8,590	17,181	106.3	212.5
		8	M997 HMMWV	2	11,550	23,101	122.4	244.9
		21	M998 HMMWV	7	8,918	62,426	109.3	765.0
		3	M998 HMMWV w/M101 Trlr	1	11,818	11,818	185.3	185.3
19	Inf Bn DS CSS Co B	2	4K Forklift	2	12,004	24,008	106.2	212.3
		10	M1043 HMMWV	2	10,458	20,916	109.8	219.6
		10	M997 HMMWV	2	11,850	23,701	122.4	244.9
		24	M998 HMMWV	6	9,218	55,308	109.3	655.7
		8	Contact Truck	2	22,200	44,400	214.4	428.8
		16	M998 HMMWV w/M101 Trlr	4	12,118	48,472	185.3	741.4
		3	MRC JTRS HMMWV	2	8,720	17,440	64.8	129.7
Totals Per Bn Task Force		1,558		237	2,604,574.4	8.760,044.2	14,594.7	49,081.7
Totals for SBME (Surface)		3,116		474	5,209,148.8	17,520,088.4	29,189.3	98,163.3

Table 7: SBME Surface BLT Composition Inserted Within Initial 10-Hour Period.

Landing Priority	Unit	# Personnel	Equipment Type	Equipment Quantity	Indiv Weight (lbs)	Total Weight (lbs)	Indiv Area (ft^2)	Total Area (ft^2)
20	Plt, HIMARS Btry	9	HIMARS Launcher	3	47,118	141,354	214.4	643.1
	Inf Bn Combat Trains	18	HIMARS Reload Veh w/Trlr	6	80,328	481,968	310.6	1863.8
		3	M1043 HMMWV	1	9,858	9,858	109.8	109.8
		24	M998 HMMWV	8	8,918	71,344	109.3	874.3
		12	M998 HWWMV w/M101 Trlr	3	12,118	36,354	185.3	556.0
		6	MRC JTRS HMMWV	2	9,170	18,340	64.8	129.7
21	Det, H&S Co, AA Bn	3	EFV-P	1	67,954	67,954	360.0	360.0
		3	EFV-C	1	64,851	64,851	360.0	360.0
		4	LVS MK48 w/MK14	2	114,050	228,099	332.7	665.3
		6	M998 HMMWV	3	8,618	25,854	109.3	327.9
		2	MRC JTRS HMMWV	1	8,870	8,870	64.8	64.8
		2	MRC JTRS HMMWV w/M116 Trlr	1	12,730	12,730	151.6	151.6
		2	MTVR w/M105 Trlr	1	52,768	52,768	310.6	310.6
		2	MTVR w/M149 WB	1	50,008	50,008	307.8	307.8
22	Det, H&S Co, Tank Bn	6	EFV-P	1	68,854	68,854	360.0	360.0
		8	EFV-C	1	66,351	66,351	360.0	360.0
		2	LVS MK48 w/MK14	1	114,050	114,050	332.7	332.7
		2	LVS MK48 w/MK17	1	114,950	114,950	319.3	319.3
		3	M1043 HMMWV	1	9,858	9,858	109.8	109.8
		6	MRC JTRS HMMWV	2	9,170	18,340	64.8	129.7
		6	MTVR w/M105 Trlr	2	53,068	106,136	310.6	621.3
		3	MTVR w/M149 WB	1	50,308	50,308	307.8	307.8
23	Det, H&S Co, LAR Bn	2	LAV 25	1	27,485	27,485	173.3	173.3
		2	LAV C2	1	27,921	27,921	174.6	174.6
		2	LAV L	1	29,609	29,609	173.5	173.5
		2	M1043 HMMWV	1	9,558	9,558	109.8	109.8
		4	M998 HMMWV	2	8,618	17,236	109.3	218.6
		3	MTVR	1	44,708	44,708	214.4	214.4
		6	MTVR w/M105 Trlr	2	53,068	106,136	310.6	621.3

Landing Priority	Unit	# Personnel	Equipment Type	Equipment Quantity	Indiv Weight (lbs)	Total Weight (lbs)	Indiv Area (ft^2)	Total Area (ft^2)
		3	MTVR w/M149 WB	1	50,308	50,308	307.8	307.8
24	Det Combat Engr (Rein)	1	D7 Dulldozer	1	49,020	49,020	208.0	208.0
		3	LVS MK48 w/MK14	1	114,350	114,350	332.7	332.7
		3	LVS MK48 w/MK16	1	69,590	69,590	294.0	294.0
		0	Trlr, Lowbed	1	40,000	40,000	466.7	466.7
		2	M998 HMMWV	2	8,318	16,636	109.3	218.6
		2	M998 HMMWV w/M116 Trlr	2	12,178	24,356	196.1	392.1
		3	MRC JTRS HMMWV	1	9,170	9,170	64.8	64.8
		3	MTVR Dumptruck	1	46,732	46,732	214.4	214.4
		3	MTVR Dumptruck w/M149 WB	1	49,332	49,332	307.8	307.8
		4	MTVR w/M105 Trlr	2	52,768	105,536	310.6	621.3
25	Tank Co DS Sec, CSS Co	2	MTVR Wrecker	1	48,033	48,033	265.3	265.3
		6	LVS MK48 w/MK14	3	114,050	342,149	332.7	998.0
		4	M88A2	1	140,704	140,704	340.5	340.5
		2	M998 HMMWV	1	8,618	8,618	109.3	109.3
		4	Contact Truck	2	21,600	43,200	214.4	428.8
		4	MTVR w/M105Trlr	2	52,768	105,536	310.6	621.3
		2	MTVR w/M149 WB	1	50,008	50,008	307.8	307.8
26	AAAV Co DS Sec CSS	6	LVS MK48 w/MK14	3	114,050	342,149	332.7	998.0
		2	M998 HMMWV	1	8,618	8,618	109.3	109.3
		2	Contact Truck	2	21,300	42,600	214.4	428.8
		6	MTVR w/M105Trlr	2	53,068	106,136	310.6	621.3
		6	MTVR w/M149 WB	2	50,308	100,616	307.8	615.5
27	LAV Co DS Sec, CSS Co	4	LVS MK48 w/MK14	2	114,050	228,099	332.7	665.3
		2	M998 HMMWV	1	8,618	8,618	109.3	109.3
		2	Contact Truck	2	21,300	42,600	214.4	428.8
		3	MTVR w/M105 Trlr	1	53,068	53,068	310.6	310.6
		3	MTVR w/M149 WB	1	50,308	50,308	307.8	307.8
28	LW155 Btry Spt Plt, CSS	8	LVS MK48 w/MK14	4	114,050	456,198	332.7	1330.6
		2	Contact Truck	1	21,600	21,600	214.4	214.4

Landing Priority	Unit	# Personnel	Equipment Type	Equipment Quantity	Indiv Weight (lbs)	Total Weight (lbs)	Indiv Area (ft^2)	Total Area (ft^2)
		4	MTVR w/M105 Trlr	2	52,768	105,536	310.6	621.3
		2	MTVR w/M149 WB	1	50,008	50,008	307.8	307.8
Totals Per Bn Task Force		1,814		340	5,510,167.6	13,771,327.8	29,423.5	73,590.5
Totals for SBME (Surface)		3,628		680	11,020,335.2	27,542,655.6	58,846.9	146,199.1

Table 8: SBME Surface BLT Composition Inserted After Initial 10-Hour Period.

Enclosure 1B: Sea Base Maneuver Element (SBME) Equipment Breakdown (Vertical BLT)

SUMMARY OF PERSONNEL AND EQUIPMENT BY LANDING SEQUENCE PRIORITY
MPF(F) MEB SEA BASED MANEUVER ELEMENT (VERTICAL)

Landing Priority	Unit	# Pax	Equipment Type	Total Weight (lbs)	Indiv Area (ft^2)	Total Area (ft^2)
1	Rifle Co 4	233	M998 HMMWV	246,296	109.3	2,404.4
2	Rifle Co 5	233	M998 HMMWV	246,296	109.3	2,404.4
3	Rifle Co 6	233	M998 HMMWV	246,296	109.3	2,404.4
4	EFSS Det	8	EFSS	42,400	88.6	708.8
5	Inf Bn Combat Trains	6	M1035 HMMWV	17,181	106.3	212.5
		8	M997 HMMWV	23,101	122.4	244.9
		21	M998 HMMWV	70,444	109.3	874.3
6	Rifle Co 7	233	M998 HMMWV	246,296	109.3	2404.4
7	LAR Co	84	LAV 25	401,590	173.3	2,425.5
		4	LAV AT	122,496	171.5	686.0
		6	LAV C2	29,121	174.6	174.6
		2	LAV L	88,287	173.5	520.6
		3	LAV M	60,094	172.2	344.4
		6	LAV R	31,103	200.0	200.0
8	CAAT Plt	24	M1043 HMMWV	96,780	109.8	1,097.9
	Scout Snipers	40	M1045 HMMWV	84,144	109.2	873.6
	TACP	32	M998 HMMWV	33,654	109.3	327.9
Totals Per Bn Task Force		1,184		2,159,642.4	2,366.4	19,182.9

Table 9: SBME Vertical BLT Composition Inserted Within Initial 10-Hour Period.

re 2

Landing Priority	Unit	# Pax	Equipment Type	Total Weight (lbs)	Indiv Area (ft^2)	Total Area (ft^2)
9	Det, H&S Co, LAR Bn	2	LAV 25	27,485	173.3	173.3
		2	LAV C2	27,921	174.6	174.6
		2	LAV L	29,609	173.5	173.5
10	Inf Bn Combat Trains (Rein)	22	M998 HMMWV	118,852	109.3	1530.1
Totals per Bn Task Force		28		203,867	630.7	2051.5

Table 10: SBME Vertical BLT Composition Inserted After Initial 10-Hour Period.

Enclosure 2: Army Brigade Combat Team Equipment Breakdown[188]

Note: Acronyms used in this enclosure are defined in a table at the end of this enclosure.

Headquarters and Headquarters Company (HHC)	Personnel	Vehicle Type					
		C2V	ICV	FCS MV-T	HMMWV (C2)	HMMWV Support	Camel (Water)
Mobile Command Group 1	14	1	1				
Mobile Command Group 2	13	1	1				
Tactical Command Post (TACP)	71	7	1		4		
Company Headquarters Section	8				1	3	2
Medical Support Section	6			1		1	
Totals	112	9	3	1	5	4	2

Brigade Intelligence and Communication (BIC) Company	Personnel	Vehicle Type			
		C2V	MULE	HMMWV (C2)	HMMWV Support
Company Headquarters Section	6	1			1
Range Extension Section	22	1	6	6	
BIC Company (NETOPS Section)	22	1		6	
BIC Company (Analysis Processing Section)	24			6	
BIC Company (Collection & Integration Section)	17	2		2	
Totals	91	5	6	20	1

Aviation Squadron	Personnel	Vehicle Type					
		C2V	HMMWV (C2)	HMMWV (Support)	RAH-66	HEMTT-LHS	AAFARS
Aviation Squadron Headquarters	31	2	2	5		1	
Aviation Flight Troop	42		2	7	6		
Aviation Flight Troop	42		2	7	6		
Aviation Service Troop (Maintenance)	77		1	20		4	
Aviation Service Troop (Support)	23			1		5	2
Totals	215	2	7	40	12	10	2

[188] Unit of Action Maneuver Battle Lab, "The United States Army Objective Force Operational and Organizational Plan Maneuver Unit of Action," Change 2 to the Army Training and Doctrine Command (TRADOC) Pamphlet 525-3-90 O & O, 30 June 2003, pp. 3-61 - 3-91.

Color Indicates - Not Fully Funded

ARMY BRIGADE COMBAT TEAM EQUIPMENT BREAKDOWN (CONTINUED)

Aviation Squadron (continued)	Vehicle Type						
	HTARS	UAV CL IVa L/C Unit	UAV CL IVa Vehicles	UAV CL IVb L/C Unit	UAV CL IVb Vehicles	Camel (Water)	HEMTT Fuelers
Aviation Squadron Headquarters						1	
Aviation Flight Troop		1	4	X*	X		
Aviation Flight Troop		1	4	X	X		
Aviation Service Troop (Maintenance)							
Aviation Service Troop (Support)	2					2	4
Totals	2	2	8	X	X	3	4

Non-Line of Sight (NLOS) Battalion	Personnel	Vehicle Type					
		C2V	HMMWV (C2)	HMMWV (Support)	HEMTT-LHS	Q64 Trailer Mtd RADAR	E-Q36 Trailer Mtd RADAR
CIC & Command Group	25	2	4	1			
NLOS LS Platoon	27			1	12		
NLOS Battery Headquarters	3			1			
Sensor Platoon	5	1					
RADAR Section	12			6		3	3
Meteorological Section	3			1			
UAV CL 3 Section	10		1		3		
Support Section	7			1	1		
NLOS Battery	48		4		12		
NLOS Battery	48		4		12		
NLOS Battery	48		4		12		
Totals	236	3	17	11	52	3	3

Color Indicates - Not Fully Funded

* “X” indicates that the required numbers are yet to be determined

ARMY BRIGADE COMBAT TEAM EQUIPMENT BREAKDOWN (CONTINUED)

NLOS Battalion (continued)	Vehicle Type							
	UAV CL III L/C Units	UAV CL III Vehicles	FCS Cannon	NLOS LS	UAV CL 1 L/C Units	UAV CL1 Vehicles	Camel (Water)	HEMTT Fuelers
CIC & Command Group							1	
NLOS LS Platoon				24				
NLOS Battery Headquarters							1	
Sensor Platoon								
RADAR Section								
Meteorological Section								
UAV CL 3 Section	3	12						
Support Section								1
NLOS Battery			6	12	2	4	1	
NLOS Battery			6	12	2	4	1	
NLOS Battery			6	12	2	4	1	
Totals	3	12	18	60	6	12	5	1

Color Indicates - Not Fully Funded

ARMY BRIGADE COMBAT TEAM EQUIPMENT BREAKDOWN (CONTINUED)

Forward Support Battalion Totals	
Personnel	453
Vehicle Type	**Total**
HMMWV (C2)	22
HMMWV (Support)	27
HEMTT-LHS	61
HMMWV Ambulance	4
MV-E	4
MV-T	3
Future Recovery Maintenance Vehicle (FRMV)	10
Camel (Water)	3
UAV CL 1 L/C	3
UAV CL 1 Vehicle	6
Hippo (Water)	5
PLS Trailer	39
POL Tank Rack	10
HEMTT Fueler	46
4K Forklift	8
10K Forklift	2
HMMWV (Contact Maintenance Truck (CMT))	11
HEMTT Wrecker	13
Forward Repair System (FRS) (LHS Mtd)	4
Set, Standard Automotive Tools (SATS) Trailer	2

ARMY BRIGADE COMBAT TEAM EQUIPMENT BREAKDOWN (CONTINUED)

Combined Arms Battalion	**Single Battalion Totals**	**3 Battalions per Unit of Action Grand Totals**
Personnel	623	1,869
Vehicle Type		
C2V	10	30
ICV	33	99
HMMWV (C2)	9	27
HMMWV (Support)	3	9
HEMMT-LHS	18	54
PLS Trailer	10	30
MV-E	5	15
MV-T	2	6
Mounted Combat System (MCS)	20	60
ARV-RSTA	9	27
MULE	18	54
MULE/GSTAMIDS	10	30
ARV-A (L)	6	18
ARV-A	6	18
Small UGV	27	81
UAV CL 1 L/C	15	45
UAV CL 1 Vehicle	30	90
UAV CL 2 L/C	12	36
UAV CL 2 Vehicle	12	36
UAV CL 3 L/C	3	9
UAV CL 3 Vehicle	12	36
NLOS Mortar	8	24
81MM Mortar	4	12
Reconnaissance and Surveillance Vehicle (R&SV)	10	30
Camel (Water)	2	6
Tank Rack (POL)	2	6
HEMMT Fueler	4	12

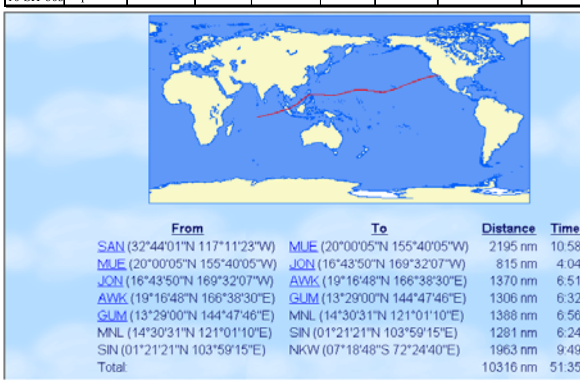
ARMY BRIGADE COMBAT TEAM EQUIPMENT BREAKDOWN (CONTINUED)

AAFARS	Advanced Aviation Forward Area Refueling System
ARV	Armed Robotic Vehicle
ARV-A	Armed Robotic Vehicle-Assault
ARV-A (L)	Armed Robotic Vehicle-Assault (Light)
ARV-RSTA	ARV-Reconnaissance, Surveillance and Target Acquisition
C2	Command and Control
C2V	Command and Control Vehicle
CIC	Command Integration Cell
CL	Class
FCS	Future Combat System
GSTAMIDS	Ground Standoff Minefield Detection System
HEMTT	Heavy Expanded Mobility Tactical Truck
HEMTT-LHS	HEMTT-Load Handling System
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HTARS	HEMMT Tanker Aviation Refueling System
ICV	Infantry Carrier Vehicle
L/C	Launcher/Control
LHS	Load Handling System
Mtd	Mounted
MULE	Multi-function Utility/Logistics and Equipment
MV-E	Medical Vehicle-Evacuation
MV-T	Medical Vehicle-Treatment
NETOPS	Network Operations
NLOS	Non-line of Sight
NLOS LS	Non-line of Sight, Launch System
PLS	Palletized Loading System
POL	Petroleum, Oil and Lubricants
RADAR	Radio Detection and Ranging
RAH-66	Comanche Helicopter
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle

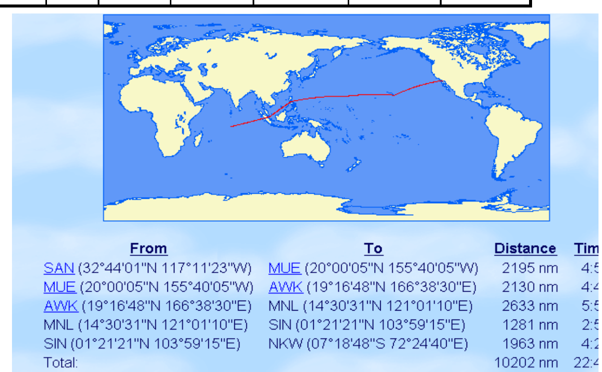
Enclosure 3: Transit Time Analysis

Transit Analysis - San Diego to Diego Garcia

Aircraft	Needed #	Reliability	A/C broken down	Round Up	Cargo A/C Arrival	Assembly Time	Depart	Destination	Distance NM	Speed Knots	Flight Time	Transit Time	Total Transit Time Hours	Total Transit Time days	Assembly + Total Transit Time
MV-22	48	0.8	9.6	10		1 Day	San Diego	Hawaii	2,195	200	10:58	RON*	10:58 + 12:00		
							Hawaii	Johnson Atoll	815	200	4:04	2 hr fuel	2		
							Johnson Atoll	Wake Island	1,370	200	6:51	RON	10:55 + 12:00		
							Wake Island	Guam	1,306	200	6:32	RON	6:32 + 12:00		
							Guam	Philippines	1,388	200	6:56	RON	14:28 +12:00		
							Philippines	Singapore	1,281	200	6:24	RON	6:24 + 12:00		
							Singapore	Diego Garcia	1,963	200	9:49	Complete			
									10,318		51:35:00		113:35:00	4 days + 18 hrs + 35 min.	5 days + 18 hrs + 35 min.
JSF	36	0.85	5.4	6		1 Day	San Diego	Hawaii	2,195	450	4:53				
							Hawaii	Wake Island	2,130	450	4:44	RON	9:34 + 12:00		
							Wake Island	Philippines	2,633	450	5:51	2 hr fuel	2		
							Philippines	Singapore	1,281	450	2:51	RON	8:31 + 12:00		
							Singapore	Diego Garcia	1,963	450	4:22	Complete			
									10,202		22:41		44:03:00	1 day + 20 hrs + 03 min.	2 day + 20 hrs + 03 min.
C-5	10	0.8	2	2	96 Hours	1 Day	San Diego	Guam	5,200	450	11:56	RON	11:56 + 12:00		
20 CH-53s	2 per C-5						Guam	Diego Garcia	4,494	450	10:00	Complete			
	1 per C-17								9,694		21:56		33:56:00	1 day + 15 hrs + 56 min.	
														+96 Hours	
															5 day + 15 hrs + 56 min.
C-17	10	0.85	1.5	2	96 Hours	1 Day	San Diego	Guam	5,200	450	11:56	RON	11:56 + 12:00		
9 UH-1Ys	4 per C-17 6 per C-5						Guam	Diego Garcia	4,494	450	10:00	Complete			
18AH-1Zs	4 per C-17 8 per C-5								9,694		21:56		33:56:00	1 day + 15 hrs + 56 min.	
														+96 Hours	
10 SH-60s	4 per C-17 6 per C-5														5 day + 15 hrs + 56 min.



MV-22 to Diego Garcia

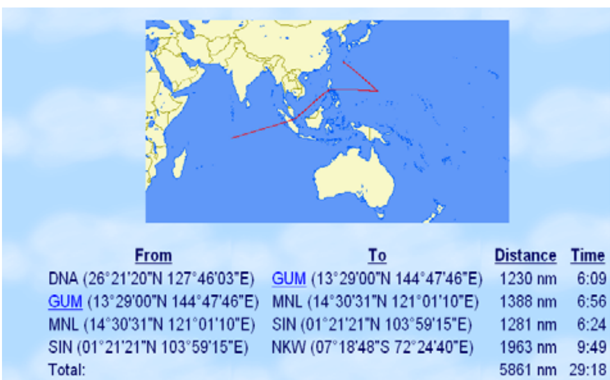


JSF to Diego Garcia

Aircraft dimensions for loading transport aircraft come from www.fas.org and www.af.mil/factsheets/factsheet
* RON: Remain Over Night

Transit Analysis - Okinawa to Diego Garcia

Aircraft	Needed #	Reliability	A/C broken down	Round Up	Cargo A/C Arrival	Assembly Time	Depart	Destination	Distance NM	Speed Knots	Flight Time	Transit Time	Total Transit Time Hours	Total Transit Time days	Assembly + Total Transit Time
MV-22	48	0.8	9.6	10		1 Day	Okinawa	Guam	1,230	200	6:09	RON*	6:09 + 12:00		
							Guam	Philippines	1,388	200	6:56	RON	6:56 + 12:00		
							Philippines	Singapore	1,281	200	6:24	RON	6:24 + 12:00		
							Singapore	Diego Garcia	1,963	200	9:49	Complete			
									5,862		29:18:00		65:18:00	2 days + 17 hrs + 18 min.	3 days + 17 hrs + 18 min.
JSF	36	0.85	5.4	6		1 Day	Okinawa	Guam	1,230	450	2:44	2 hr fuel	2		
							Guam	Philippines	1,388	450	3:05	2 hr fuel	2		
							Philippines	Singapore	1,281	450	2:51	RON	8:40 + 12:00		
							Singapore	Diego Garcia	1,963	450	4:22	Complete			
									5,862		13:02		29:02:00	1 day + 5 hrs + 02 min.	2 day + 5 hrs + 02 min.
C-5	10	0.8	2	2	96 Hours	1 Day	Okinawa	Guam	1,230	450	2:44	2 hr fuel	2		
20 CH-53s	2 per C-5						Guam	Diego Garcia	4,494	450	10:00	Complete			
	1 per C-17								5,724		12:44		14:44:00	1 day + 96 hrs	5 day + 14 hrs + 44 min.
C-17	10	0.85	1.5	2	96 Hours	1 Day	Okinawa	Guam	1,230	450	2:44	2 hr fuel	2		
9 UH-1Ys	6 per C-5						Guam	Diego Garcia	4,494	450	10:00	Complete			
18 AH-1Zs	4 per C-17 8 per C-5								5,724		12:44		14:44:00	1 day + 96 hrs	5 day + 14 hrs + 44 min.
10 SH-60s	4 per C-17 6 per C-5														



MV-22 to Diego Garcia

JSF to Diego Garcia

Aircraft dimensions for loading transport aircraft come from www.fas.org and www.af.mil/factsheets/factsheet
* RON: Remain Over Night

Analysis of Tanker Support to Diego Garcia

Aircraft	Fuel (lbs)	Type A/C Supported	Fuel Consumption Rate (lbs/hr)	Flight hours required	Number of A/C Supported	Fuel needed	Number of Tankers Needed	Round up	Tanker Reliabilitly	Number of Tankers Needed	Round up
KC-10A	342,000	JSF	6,000	4	36	864,000	2.526315789	3	0.85	3.529411765	4
KC-135R	120,000	JSF	6,000	4	36	864,000	7.2	8	0.85	9.411764706	10

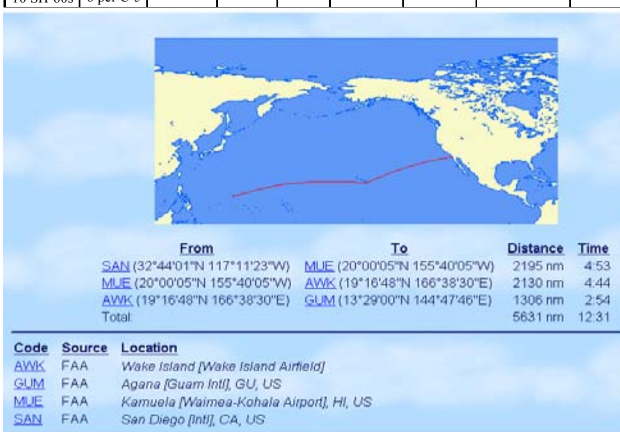
KC-130	66,000	MV-22	3,000	9	48	1,296,000	19.63636364	20	0.8	25	25
KC-10A	342,000	MV-22	3,000	9	48	1,296,000	3.789473684	4	0.85	4.705882353	5
KC-135R	120,000	MV-22	3,000	9	48	1,296,000	10.8	11	0.85	12.94117647	13

Tanker flight times will be equal to the aircraft they are refueling

Fuel loads for tankers come from www.fas.org

Transit Analysis - San Diego to Guam

Aircraft	Needed #	Reliability	A/C broken down	Round Up	Cargo A/C Arrival	Assembly Time	Depart	Destination	Distance NM	Speed Knots	Flight Time	Transit Time	Total Transit Time Hours	Total Transit Time days	Assembly + Total Transit Time
MV-22	48	0.8	9.6	10		1 Day	San Diego	Hawaii	2,195	200	10:58	RON*	10:58 + 12:00		
							Hawaii	Johnson Atoll	815	200	4:04	2 hr fuel	2		
							Johnson Atoll	Wake Island	1,370	200	6:51	RON	10:55 + 12:00		
							Wake Island	Guam	1,306	200	6:32	Complete			
									5,686		28:25:00		54:25:00	2 days + 6hrs + 25 min.	3 days + 6 hrs + 25 min.
JSF	36	0.85	5.4	6		1 Day	San Diego	Hawaii	2,195	450	4:53	2 hr fuel	2		
							Hawaii	Wake Island	2,130	450	4:44	2 hr fuel	2		
							Wake Island	Guam	1,306	450	2:54	Complete			
									5,631		12:31		16:31:00	1 day	1 day + 16 hrs + 31 min.
C-5	10	0.8	2	2	96 Hours	1 Day	San Diego	Guam	5,200	450	11:56				
20 CH-53s	2 per C-5										11:56	Complete	11:56:00	1 day + 96 hours	5 day + 11 hrs + 56 min.
	1 per C-17														
C-17	10	0.85	1.5	2	96 Hours	1 Day	San Diego	Guam	5,200	450	11:56				
9 UH-1Ys	4 per C-17 6 per C-5										11:56	Complete	11:56	1 day + 96 hours	5 day + 11 hrs + 56 min.
18 AH-1Zs	4 per C-17 8 per C-5														
10 SH-60s	4 per C-17 6 per C-5														



JSF to Guam

MV-22 to Guam

Aircraft dimensions for loading transport aircraft come from www.fas.org and www.af.mil/factsheets/factsheet

* RON: Remain Over Night

Transit Analysis - Okinawa to Guam

Aircraft	Needed #	Reliability	A/C broken down	Round Up	Cargo A/C Arrival	Assembly Time	Depart	Destination	Distance NM	Speed Knots	Flight Time	Transit Time	Total Transit Time Hours	Total Transit Time days	Assembly + Total Transit Time
MV-22	48	0.8	9.6	10		1 Day	Okinawa	Guam	1,230	200	6:09	Complete			
											6:09		6:09	1 day	1 days + 6 hrs +09 min.
JSF	36	0.85	5.4	6		1 Day	Okinawa	Guam	1,230	450	2:44	Complete			
											2:44		2:44	1 day	1 day + 2 hrs +44 min.
C-5	10	0.8	2	2	96 Hours	1 Day	Okinawa	Guam	1,230	450	2:44	Complete			
20 CH-53	2 per C-5 1 per C-17										2:44		2:44	1 day + 96 hours	5 day + 2 hrs +44 min.
C-17	10	0.85	1.5	2	96 Hours	1 Day	Okinawa	Guam	1,230	450	2:44	Complete			
9 UH-1Ys	4 per C-17 6 per C-5										2:44		2:44	1 day + 96 hours	5 day + 2 hrs +44 min.
18 AH-1Zs	4 per C-17 8 per C-5														
10 SH-60s	4 per C-17 6 per C-5														

MV-22 to Guam

JSF to Guam

Aircraft dimensions for loading transport aircraft come from www.fas.org and www.af.mil/factsheets/factsheet

Analysis of Tanker Support to Guam

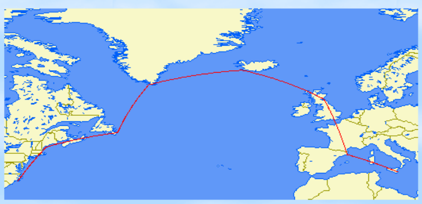
Aircraft	Fuel (lbs)	Type A/C Supported	Fuel Consumption Rate (lbs/hr)	Flight hours required	Number of A/C Supported	Fuel needed	Number of Tankers Needed	Round up	Tanker Reliabilitly	Number of Tankers Needed	Round up
KC-10A	342,000	JSF	6,000	3	36	648,000	1.894736842	2	0.85	2.352941176	3
KC-135R	120,000	JSF	6,000	3	36	648,000	5.4	6	0.85	7.058823529	8
KC-130	66,000	MV-22	3,000	9	48	1,296,000	19.63636364	20	0.8	25	25
KC-10A	342,000	MV-22	3,000	9	48	1,296,000	3.789473684	4	0.85	4.705882353	5
KC-135R	120,000	MV-22	3,000	9	48	1,296,000	10.8	11	0.85	12.94117647	13

Tanker flight times will be equal to the aircraft they are refueling

Fuel loads for tankers come from www.fas.org

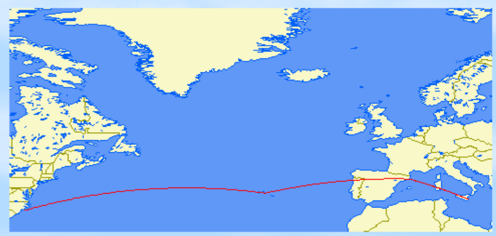
Transit Analysis - Cherry Point to Sigonella

Aircraft	Needed #	Reliability	A/C broken down	Round Up	Cargo A/C Arrival	Assembly Time	Depart	Destination	Distance NM	Speed Knots	Flight Time	Transit Time	Total Transit Time Hours	Total Transit Time days	Assembly + Total Transit Time
MV-22	48	0.8	9.6	10		1 Day	Cherry Point	Brunswick	628	200	3:08	2 hr fuel	2		
							Brunswick	Saint. John's	754	200	3:46	2 hr fuel	2		
							Saint John's	Greenland	798	200	4:00	RON*	12:54 + 12:00		
							Greenland	Keflavic	674	200	3:22	2 hr fuel	2		
							Keflavic	Scottland	743	200	3:43	2 hr fuel	2		
							Scottland	Rota	896	200	4:29	RON	13:34 + 12:00		
							Rota	Sigonella	624	200	3:07	Complete			
									5,117		25:35:00		57:35:00	2 days + 9hrs + 35 min.	3 days + 9 hrs + 35 min.
JSF	36	0.85	5.4	6		1 Day	Cherry Point	Azores	2,380	450	5:17	2 hr fuel	2		
							Azores	Rota	1,376	450	3:03	2 hr fuel	2		
							Rota	Sigonella	624	450	1:23	Complete			
									4,380		9:44		13:56:00	1 day	1 days + 13 hrs + 56 min.
C-5	10	0.8	2	2	96 Hours	1 Day	Cherry Point	Sigonella	4,267	450	9:29	Complete	9:29	1 day + 96 hours	5 days + 9 hrs + 29 min.
20 CH-53s	2 per C-5														
	1 per C-17														
C-17	10	0.85	1.5	2	96 Hours	1 Day	Cherry Point	Sigonella	4,267	450	9:29	Complete	9:29	1 day + 96 hours	5 days + 9 hrs + 29 min.
9 UH-1Ys	4 per C-17 6 per C-5										9:29				
18AH-1Zs	4 per C-17 8 per C-5														
10 SH-60s	4 per C-17 6 per C-5														



From	To	Distance	Time
NKT (34°54'10"N 76°52'52"W)	NHZ (43°53'32"N 69°56'19"W)	628 nm	3:08
NHZ (43°53'32"N 69°56'19"W)	YYT (47°37'07"N 52°45'07"W)	754 nm	3:46
YYT (47°37'07"N 52°45'07"W)	JNN (60°09'N 45°13'W)	798 nm	3:59
JNN (60°09'N 45°13'W)	KEF (63°59'06"N 22°36'20"W)	674 nm	3:22
KEF (63°59'06"N 22°36'20"W)	ADX (56°22'22"N 02°52'06"W)	743 nm	3:43
ADX (56°22'22"N 02°52'06"W)	GRO (41°54'03"N 02°45'38"E)	896 nm	4:29
GRO (41°54'03"N 02°45'38"E)	NSY (37°24'06"N 14°55'20"E)	624 nm	3:07
Total:		5117 nm	25:35

MV-22 to Sigonella



From	To	Distance	Time
NKT (34°54'10"N 76°52'52"W)	TER (38°45'43"N 27°05'27"W)	2380 nm	5:17
TER (38°45'43"N 27°05'27"W)	GRO (41°54'03"N 02°45'38"E)	1376 nm	3:03
GRO (41°54'03"N 02°45'38"E)	NSY (37°24'06"N 14°55'20"E)	624 nm	1:23
Total:		4380 nm	9:44

JSF to Sigonella

Aircraft dimensions for loading transport aircraft come from www.fas.org and www.af.mil/factsheets/factsheet
*RON: Remain Over Night

Analysis of Tanker Support to Sigonella

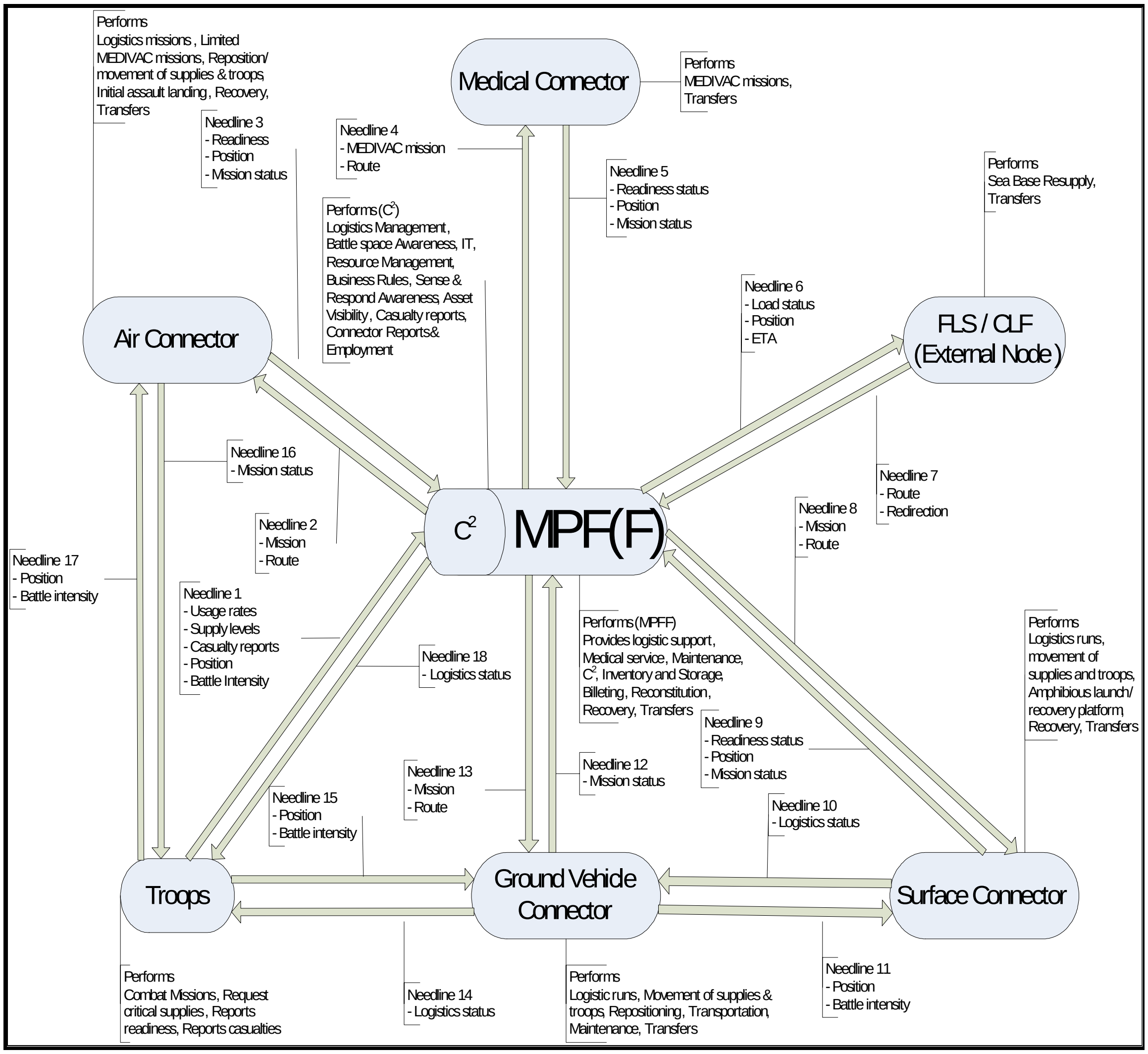
Aircraft	Fuel (lbs)	Type A/C Supported	Fuel Consumption Rate (lbs/hr)	Flight hours required	Number of A/C Supported	Fuel needed	Number of Tankers Needed	Round up	Tanker Reliabilitly	Number of Tankers Needed	Round up
KC-10A	342,000	JSF	6,000	4	36	864,000	2.526315789	3	0.85	3.529411765	4
KC-135R	120,000	JSF	6,000	4	36	864,000	7.2	8	0.85	9.411764706	10

KC-130	66,000	MV-22	3,000	3	48	432,000	6.545454545	7	0.8	8.75	9
KC-10A	342,000	MV-22	3,000	3	48	432,000	1.263157895	2	0.85	2.352941176	3
KC-135R	120,000	MV-22	3,000	3	48	432,000	3.6	4	0.85	4.705882353	5

Tanker flight times will be equal to the aircraft they are refueling

Fuel loads for tankers come from www.fas.org

Enclosure 4: OV-2 JELo Operational Node Connectivity



6. 2015 BASELINE ARCHITECTURE RELIABILITY, AVAILABILITY, AND MAINTAINABILITY ANALYSIS

6.1 Overview

This analysis evaluates the reliability of the 2015 Baseline Architecture (2015 BLA) as defined by SEA-6. It also provides insight into the architecture by identifying the major functional subsystems that would most benefit from improved reliability.

This analysis is performed on the 2015 BLA during the sustainment phase. The 2015 BLA constitutes a system of systems. Where available, SEA-6 uses system component reliability, availability, or maintainability data. Where not available, system characteristics are assumed based on estimates made by analogy with existing systems or operational experience to determine system distribution and parameters. These simplifying assumptions may not hold true when actual system-level data becomes available. However, these assumptions allow back of the envelope calculations that provide useful insight to system requirements and performance. Additionally, the Systems Engineering Analysis Baseline Architecture System Evaluator Six (SEABASE-6) model, described in Chapter 8, serves as a tool to perform follow-on reliability analysis. Architecture components can be analyzed based on a user-defined distribution and parameters. A reliability analysis was performed using SEABASE-6 for the reliability of the LCAC as a surface assault connector. The result of this analysis is presented in Chapter 11.

SEA-6 uses the reliability, availability, and maintainability analysis techniques taught at the Naval Postgraduate School. Drenick's Theorem is used to model the systems and subsystems with an exponential distribution of failure times. This theorem states that the distribution of times between failures for a complex, repairable system that has already been repaired several times is well modeled by the exponential distribution. Therefore, Eqn 6-1 can be used to estimate individual system reliability.

[Eqn 6-1] $$R(t) = e^{-\left(\frac{missiontime}{MTBF}\right)}.$$

Where MTBF is the Mean Time Between Failure and mission time is set for 30 days. *R(t)* is the reliability of the system where *t* corresponds to the desired mission time.

All systems, subsystems, and components are assumed to be independent of each other. Using this assumption, the reliability of series systems is calculated by taking the product of the individual reliabilities. Parallel system reliabilities are calculated by:

[Eqn 6-2] $$R(t)_S = 1-(1-R(t)_{S1})(1-R(t)_{S2})(1-R(t)_{S3})...(1-R(t)_K).$$

$R(t)_S$ is the overall system reliability. $R(t)_{S1}$, $R(t)_{S2}$, $R(t)_{S3}$ … $R(t)_K$ is the reliability of the individual subsystems numbered 1 through *k* over a specified length of time.

Systems that only require a portion of the total numbers available are k-of-n systems. The reliability of these systems if identically distributed and of same age is calculated by use of the binomial distribution shown as Eqn 6-3.

[Eqn 6-3] $$R(t)_S = (k, n, R(t))\sum_{r=k}^{n}\binom{n}{r}R(t)^r(1-R(t))^{n-r},$$

where *k* is the number of items required, *n* is the total number of items, and *R* is the individual reliability of each item (calculated with Eqn 6-1).

Since some of the 2015 BLA systems are conceptual, actual availability data is obtainable for only those systems in existence today. Availabilities are estimated by analogy with existing systems tempered with fleet experience. For simplicity of calculation, the expression for asymptotic average availability, A_∞, is used in lieu of point availability.

[Eqn 6-4] $$A_\infty = \frac{MTBF}{MTBF + MTTR + MLOG}.$$

MTTR is the Mean Time To Repair and MLOG is the Mean Logistics delay. Eqn 6-4 can be rearranged to solve for MTBF in terms of availability and maintainability information:

[Eqn 6-5] $$MTBF = \frac{A_\infty \times (MTTR + MLOG)}{(1 - A_\infty)}.$$

6.2 Sustainment Phase System Definition

The 2015 BLA is described in detail in Chapter 5. The portion of the architecture used for analysis is the combined set of functional systems and processes that combine to build the systems of systems used during the Sustainment phase of Joint Expeditionary Operations. During sustainment operations, a resupply item flows through the functional systems of the 2015 BLA following the series path shown in Figure 6-1. The command and control (C2) system senses the need for a particular supply. The Inventory and Storage (I & S) system finds and makes available the supply item. The transfer system (XFER) represents the systems that interface between platforms and connectors. The first XFER block represents the transfer system that transfers the supply item to an available logistic connector. The logistic connector (TOR) block represents systems that carry the supply items to the objective. The second XFER block represents the transfer systems that remove the supply items from the connector at the objective.

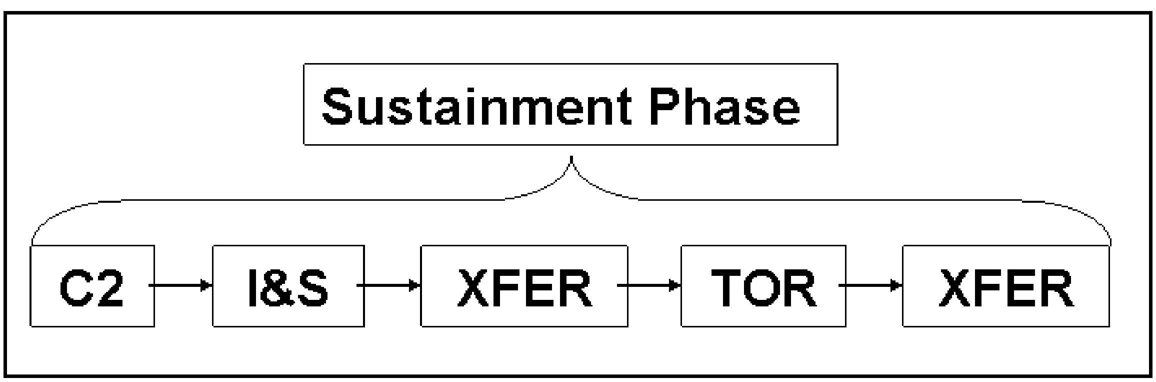


Figure 6-1: 2015 Baseline Architecture Sustainment Phase Block Diagram.

The logistics system's performance during the Sustainment phase is measured in Days of Supply (DOS). A failure of this system is defined by the inventory ashore of any class of supply (food, water, fuel, or ammunition) falling below 1 DOS.

6.2.1 Sustainment Phase System Model

The 2015 BLA Sustainment phase system is modeled as an Economic Order Quantity (EOQ) Inventory system with periodic review. The periodic review relies on a known supply quantity on hand (*OH*) at a fixed review interval, *T*. An order-up-to-level, defined as *R*, is set to reflect the maximum amount of supplies maintainable at the objective. Figure 6-2 shows a graphical representation of this model type. The difference between *R* and *OH* determines the amount of supplies needed; *Q*, for the next time interval. The 2015 BLA must perform within this logistics policy.

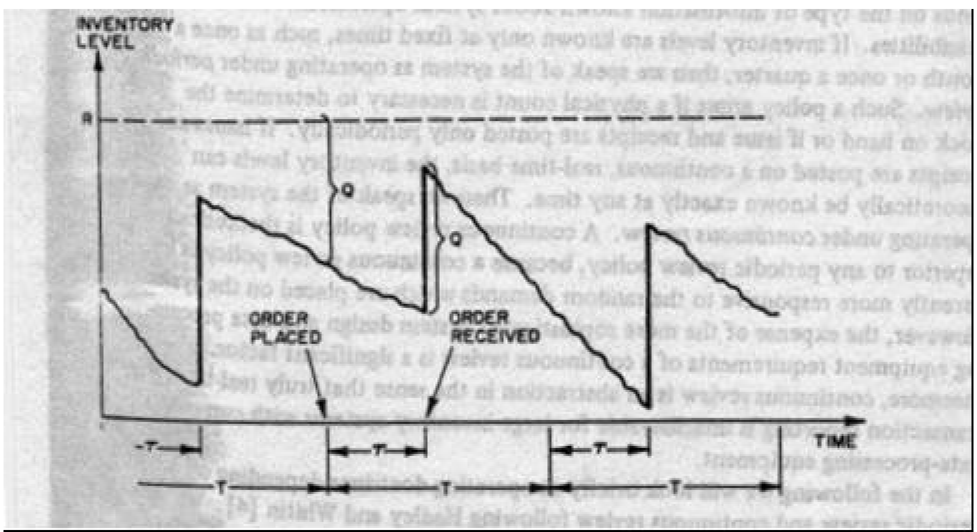


Figure 6-2: EOQ Model with Periodic Review.[189]

6.3 Sustainment System Requirement Analysis

The logistics system fails if supplies get too low or too high. Operational pauses for logistics and "Iron Mountains" of supplies at the objective are both critical vulnerabilities. Maintaining less than three days' supply level at the objective enables force mobility and agility without excessive inventory. However, shortages at the

[189] Schrady, David, OS 4580 Course Notes, p. 5-3.

objective cannot be tolerated as well. This high-level system requirement can be quantified in the following inventory policy.

The Joint Expeditionary Brigade (JEB) deploys to the objective with three DOS, so the "initial inventory" is three DOS ($R = 3$). To maintain the inventory at the objective and to handle the occasional high demand situation, the 2015 BLA has the capacity to provide a minimum of 1 1/2 DOS to the objective per day. Based on USMC planning factors,[190] 1 DOS of food, water, ammunition, and fuel totals 767 short tons, which yields 1,151 short tons for the 1 1/2 DOS. Thirty days of continuous sustainment at the objective for the 3 Battalion Landing Teams (BLTs) equates to 23,010 short tons.

To achieve 30 days of sustainment at a maximum delivery rate of 1 1/2 DOS per day requires the 2015 BLA to supply for a minimum of 20 out of 30 days. While the goal is to deliver 1 DOS per day, a surge capability of 50% is added to account for increased combat operations. This equates to an operational availability of 67% during the 30-day sustainment phase. Additionally, the 2015 BLA sustainment system cannot be down for more than 2 1/2 consecutive days without creating shortages at the objective. Therefore, the combined MTTR + MLOG of the system cannot exceed 2 1/2 days.

To quantify the relationship between MTTR and MLOG, assume that the summation of MTTR and MLOG also follows an exponential distribution.[191] This assumption is used to simplify the calculations required to perform this back of the envelope calculation and quantify the overall system of systems performance. Further, assume that the system satisfies the requirement greater than 90% of the time. The expected value of the sum of MTTR and MLOG is estimated.

Let s = (MTTR + MLOG) follow an exponential distribution with mean = $1/\lambda_{S.}$

Find the MTBF that makes s less than 2 1/2 days 90% of the time,

$P(s \leq 2.5) \geq 0.90.$

[190] MCCDC, MAGTF Planner's Reference Manual, Part IV.
[191] Blanchard, Benjamin S. and Fabrycky, Wolter J., Systems Engineering and Analysis, Third Edition. (New Jersey: Prentice Hall, 1998), p. 408.

This is found by taking 1- (probability that s is greater than 2 1/2 days):

$1 - e^{-\lambda_S (2.5)} \geq 0.90.$

Solving for λ_S: $\lambda_S \geq 0.92$

Therefore, the desired expected value of (MTTR + MLOG) is

$1/\lambda_S = 1.1$ days ≈ 26 hrs.

Based on a 30-day mission time, the sustainment system MTBF must be greater than 30 days (720 hrs) 90% of the time. Using the same steps as above, the expected value of the 2015 BLA MTBF is estimated.

$P(MTBF \leq 720) \leq 0.10$

$1 - e^{-\lambda_M (720)} \leq 0.10$

$\lambda_M \geq 0.00015$

Therefore, the expected value of MTBF = $\dfrac{1}{\lambda_M} = 6{,}834$ hrs ≈ 285 days.

In other words, the logistics system must have an average MTBF of at least 285 days to maintain the desired inventory policy. Because there is no actual data for the 2015 BLA, its availability is estimated using Eqn 6-4 and the MTBF, MTTR, and MLOG estimates above: $A_\infty = 0.996$.

Since 0.996 is greater than the requirement threshold of 0.67, the 2015 BLA is expected to be available more than the minimum time required to deliver the minimum amount of logistics to the objective.

6.4 Command and Control System Analysis

The Center for Naval Analysis (CAN) Maritime Prepositioning Force (Future) (MPF(F) Analysis of Alternative (AoA) suggests that 2 MPF(F) ships in a squadron will have the major C2 system components.[192] Figure 6-3 shows a generic composition of the C2 system for these 2 MPF(Fs).

[192] Souders et al., pp.22-23.

* Transmitter(s)
* Receiver(s)
* Users
1 Network
* Software

Platform

2 MPF(F)
For C2

1 JELo System

* Transmitter(s)
* Receiver(s)
* Users
1 Network
* Software

Platform

Figure 6-3: Example Command and Control System.

As described in Chapter 5, the system consists of many (*) transmitters, receivers, users, and software applications (* listed by these items in Figure 6-3). Each ship has its own Global Command Control System-Joint (GCCS-J) network. These networks are tied together via the Global Information Grid (GIG)). The network's reliability is estimated based on the functional relationships shown in Figure 6-4.

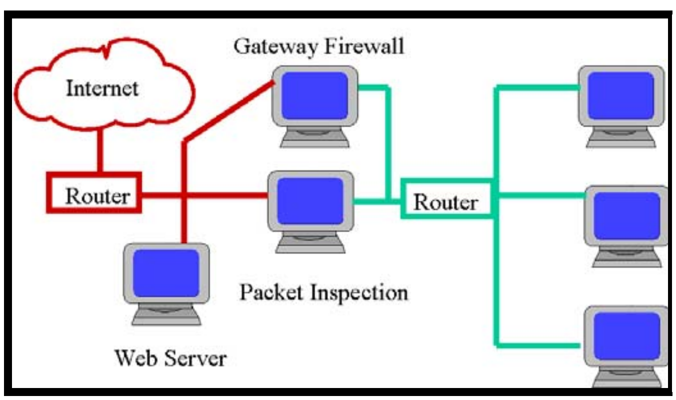


Figure 6-4: Generic Network Architecture Diagram.[193]

[193] Sample, Char and Sample, Keith, Network Reliability and Availability Issues, Charmark, Inc., 1998.

6.4.1 Command and Control Reliability Estimate

The reliability of this system is calculated using reliability estimates for each of the subsystems. MTBFs[194] for the major subsystems are estimated from current commercial systems:

External Router MTBF = 47,600 hrs

Firewall MTBF = 50,000 hrs

Gateway MTBF = Web MTBF = 26,000 hrs

MTBF (Internal Router) = 52,000 hrs

Using these MTBFs, the Sustainment mission time of 30 days (720 hrs), and Eqn 6-1, the estimated subsystem reliabilities are:

$R(t)_{ext\ router} = 0.985$

$R(t)_{firewall} = 0.986$

$R(t)_{gateway} = R(t)_{web} = 0.973$

$R(t)_{int\ router} = 0.986$

Because all of these components have to work for the system to work, the system in Figure 6-4 is modeled as a series system. Using this model, the overall reliability is the product of the subsystem reliabilities:

$R(t) = R(t)_{ext\ router} * R(t)_{firewall} * R(t)_{gateway} * R(t)_{web} * R(t)_{int\ router}$

$R(t) = 0.985 * 0.986 * 0.973 * 0.973 * 0.986 =$ **0.907**

This is the reliability of a single ship C2 system. Using the two-ship model, the C2 reliability becomes:

$R(t)_{C2} = 0.907 * 0.907 =$ **0.823.**

[194] Ibid.

This is less than the 0.9 reliability threshold desired. However, if the network is set up with two parallel loops, system reliability becomes:

$$R(t)_{C2} = 1 - (1\text{-}R(t)_1)*(1\text{-}R(t)_2) = 1 - (0.093)*(0.093) = \mathbf{0.991.}$$

Based on this assumed configuration, to achieve network reliability > 0.9, at least two independent network paths are required on each MPF(F).

6.4.2 Command and Control Maintainability

From Section 6.3, MTTR + MLOG for the C2 system needs to be less than 60 hrs. This MTTR requirement assumes that the technician, parts, publications, documentation, tools, etc. are all available at the time of repair.

6.4.3 Command and Control Availability

Also from Section 6.3, the logistic system must have an operational availability (A_o) greater than 0.67. Using Eqn 6-4, the MTBF values from Section 6.5.1, and the MTTR+MLOG value of 60 hrs from Section 6.3, the overall C2 availability is estimated to be A_o = 0.998.

6.5 Inventory and Storage System Analysis

As discussed in Chapter 5, the I & S System of each MPF(F) ship consists of three subsystems: three elevators, various Material Handling Equipment (MHE), and the Inventory Management System (IMS). Figure 6-5 depicts the overall I & S system.

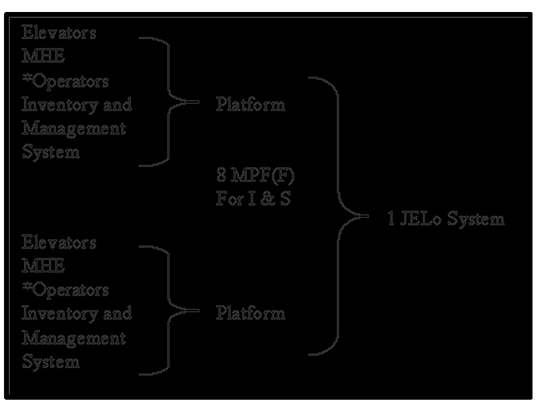


Figure 6-5: I & S System Illustration Across One Squadron of MPF(F).
***Note:** Operator reliability is not estimated.

6.5.1 Inventory and Storage Reliability Estimate

Each MPF(F) ship has three elevators. The three elevators are modeled as a parallel system because all elevators have access to all storerooms. At least one elevator per ship has to work to perform strike up/down. A system failure is defined as an elevator not being able to lift cargo/stores.

Elevator MTBF is estimated from the elevator availability. From fleet experience, a given elevator is down approximately 1 out of 30 days; an availability of 0.967.

Also from fleet experience, a failed elevator takes, on average, one day to repair: MTTR + MLOG ≈ 24 hrs. Using these values in Eqn 6-5 gives an MTBF for a single elevator of ~ 703 hrs. Substituting this MTBF value and the mission time of 720 hrs into Eqn 6-1 gives an individual elevator reliability:

$$R(t)elevator = e^{-(720/703)} = 0.36.$$

Using this value in Eqn 6-2 for parallel systems:

$$(1 – (1-.36)*(1-.36)*(1-.36)) = 0.737.$$

Therefore, an MPF(F) equipped with three elevators has an estimated elevator reliability of 0.74.

The MHE subsystem is modeled as a k-of-n system, based on at least 4 working forklifts/pallet jacks from a pool of at least 8 forklifts and 12 pallet jacks per MPF(F). A failure is defined as a forklift or pallet jack that is not able to move cargo/stores.

From fleet experience, a forklift is down, on average, 1 out of 60 days and takes half a day to repair; an approximate availability of 0.983 and MTTR + MLOG of 12 hrs. From Eqn 6-5, the MTBF for a single forklift is estimated to be ~ 588 hrs. Additionally, a pallet jack fails on average 1 out of 180 days and takes half a day to repair; an approximate availability of 0.994 and MTTR + MLOG of 12 hrs. Again, from Eqn 6-5, the MTBF for a single pallet jack is estimated to be ~ 2,154 hrs.

Using Eqn 6-1 with these values gives an individual item reliability of 0.29 for the forklift and 0.72 for the pallet jack. On average, four MHE items are needed to pull items from inventory. The MHE is a *k* of *n* system where any combination of $k = 4$ will suffice. Using Eqn 6-3, the MHE reliability becomes 0.99.

Because the Inventory Management System (IMS) uses much of the infrastructure of the C2 system in Section 6.5, it is assumed to have the same reliability: R(t) Inventory sys = 0.99.

This system's reliability is estimated using estimates for the reliability of the subsystems and components. The three subsystems are modeled in series because they must work together to accomplish I & S mission. The overall reliability is the product of the subsystem reliabilities:

$$R(t) = R(t)_{elevator} * R(t)_{MHE} * R(t)_{\text{Inventory sys}}$$

$$R(t) = 0.74 * 0.99 * 0.99 = \mathbf{0.73}$$

This is the reliability of each ship's system. The overall architecture of 8 ships is a *k*-of-*n* system, where at least 4 of the 8 MPF(F) ships are required to move stores. Using Eqn 6-3 with $k = 4$, $n = 8$, and $R(t) = 0.73$, the I & S reliability is then 0.86.

6.5.2 Inventory and Storage Maintainability

Again, by analogy with the C2 system, the maintainability (MTTR + MLOG) is estimated to be 60 hrs.

6.5.3 Inventory and Storage Availability

Also from Section 6.3, the logistic system must have an operational availability (A_o) greater than 0.67. Using Eqn 6-4, the MTBF values from Section 6.6.1, and the MTTR+MLOG value of 60 hrs from Section 6.3, the overall I & S availability is estimated to be $A_o = 0.988$.

6.6 Transfer System Analysis

Three subsystems comprise the 2015 BLA transfer system: air transfers, surface STREAM transfers, and surface crane transfers. Each of these three subsystems has two components: the sending component and the receiving component. To simplify the analysis, both components are assumed identically distributed. This assumption is reasonable for the air transfers since the helicopters are using a sling to pick up and drop off pallet loads. Because any two ships use the same STREAM system, the identical assumption holds there too. The assumption is questionable for the cranes and for LCACs loading at an Integrated Landing Platform (ILP). It is also questionable for unloading.

6.6.1 Transfer System Reliability

The transfer system reliability is estimated by applying a complexity factor[195] to the overall 2015 BLA. Based on the relative simplicity of the transfer mechanisms (pallet jacks, ramps, forklifts, STREAM underway replenishment, etc.) the transfer system represents an estimated 15% of the overall complexity of the 2015 BLA. This complexity factor is applied to the overall architecture failure rate to calculate the transfer system failure rate:

$$\lambda_{JELo} = 1/MTBF = 1/30days = .0333$$
$$\lambda_{Xfers} = \lambda_{JELo} * CF = .0333 * .15 = .005$$

$$\lambda_{Xfer} = 1/MTBF$$
$$MTBF = 1/\lambda_{Xfer} = 1/.005 = 200days = 2400hours$$

Using this MTBF value and Eqn 6-1 for a mission time of 720 hrs, transfer system reliability is **0.78.**

The same reliability allocation approach is used to estimate the reliability of each transfer subsystem where weighted complexity factors (CF) are assigned to the

195 Benjamin S. Blanchard, Logistics Engineering and Management (Upper Saddle River, NJ: Prentice Hall, 1998), p. 140.

subsystems. Air transfers (Vertical Replenishment (VERTREP) slings), very mature and simple systems, are assigned a CF of 0.05. The standard STREAM underway replenishment system, also mature and slightly more complex, is assigned 0.15. However, the MPF(F) sea-state-compensating crane subsystems, both technologically risky and highly complex, are assigned a CF of 0.80.

For the Air Transfers, the reliability of each end of the system is estimated by multiplying the overall transfer failure rate (λ) by the CF to get the Air Transfer failure rate. The reciprocal of this value is the MTBF, used in Eqn 6-1 to estimate Air Transfer reliability.

$\lambda_{AirXfer} = \lambda_{Xfer} * 0.05 = .005 * 0.05 = .00025$

$MTBF_{AirXfer} = 1/\ \lambda_{AirXfer} = 1/(.00025) = 4{,}000$ days $= 96{,}000$ hrs

Substituting a mission time of 720 hrs and the MTBF of 96,000 hrs into Eqn 6-1 gives an estimated Air Transfer reliability of 0.99. Using the same approach for the STREAM system:

$\lambda_{AirXfer} = \lambda_{Xfer} * 0.15 = .005 * 0.15 = .0075$

$MTBF_{STREAM} = 1/\ \lambda_{STREAM} = 1/(.0075) = 133$ days $= 3{,}200$ hrs

Substituting a mission time of 720 hrs and the MTBF of 3,200 hrs into Eqn 6-1 gives an estimated STREAM reliability of 0.80. Likewise for the Surface Crane System:

$\lambda_{Crane} = \lambda_{Crane} * 0.8 = .005 * 0.8 = .004$

$MTBF_{Crane} = 1/\ \lambda_{Crane} = 1/(.004) = 250$ days $= 6{,}000$ hrs

Substituting a mission time of 720 hrs and the MTBF of 6,000 hrs into Eqn 6-1 gives an estimated Surface Crane System reliability of 0.89. The series combination of these subsystems is slightly less than the overall approximation of 0.78 above:

$R(t)_{Xfer} = 0.99 * 0.80 * 0.89 = 0.70.$

6.6.2 Transfer System Maintainability

As discussed in Section 6.3, the maintainability of the sustainment system must be less than 2.5 days (MTTR + MLOG).

6.6.3 Transfer System Availability

Using Eqn 6-4 with an MTBF of 200 days and maintainability (MTTR + MLOG) of 2 1/2 days, the estimated availability of the transfer system equates to 0.988.

6.7 Connector System Analysis

This section estimates the logistics system's air connector reliability. Only the air connectors are used for sustainment, thus this analysis only considers those connectors. The overall Air Connector Sustainment system is modeled as shown in Figure 6-6.

Figure 6-6: Air Connector Reliability Block Diagram.

The 2015 BLA is designed such that the Air Connector System (the MV-22 squadrons and the CH-53X squadrons) sustains the JEB ashore. The mission is to deliver one DOS per day with a surge capability of up to 1 1/2 DOS to the JEB ashore in any 24-hr day. The analysis will look at the 1 1/2 DOS delivery rate to obtain the maximum system performance. Therefore, a "failure" of the logistic system occurs when less than 1 1/2 DOS are provided to the JEB ashore in a given 24-hr period. The 2015 BLA consists of eight MPF(F) that operate on two 12-hr shifts. For a given 12-hr shift, 4 MPF(Fs), with one 10-plane CH-53X squadron and two 12-plane MV-22s, must provide half of 1 1/2 DOS or three-quarters DOS. Using the BLA planning factors [Chapter 5], three-quarters DOS for the 3 BLTs is as follows:

1 DOS food = 27,113 lbs

1 DOS fuel = 134,000 gals x (6.8 lbs/gal) = 911,200 lbs

1 DOS water = 34,013 gals x (8.3 lbs/gal) = 282,308 lbs

1 DOS ammo = 312,000 lbs

Aggregate DOS = 1,532,621 lbs ≈ 1,533,000 lbs

1.5 DOS ≈ 2,300,000 lbs

¾ Aggregate DOS = (0.75)*(1,533,000 lbs) = 1,150,000 lbs

This quantity is converted into CH-53X payloads: number of CH-53X payloads = (¾ DOS lbs)/(CH-53X capacity lbs) where CH-53X external capacity is 25,500 lbs at 100 nm = (1,150,000 lbs)/(25,500 lbs) ≈ 46 payloads. Each payload represents a round-trip from the Sea Base to the objective and back. To calculate the time required for an individual trip:

Time per trip = ((2*Radius)/(Average trip speed)) + Load-unload delay.

If each aircraft spends 6-12 minutes on each end of the trip picking up and dropping off its load, on average 12-24 minutes for each trip is spent loading and unloading palletized loads.

An MV-22 flies 100 kts to the objective with an external load and 240 kts back from the objective, for an average trip speed of approximately 170 kts.

A CH-53X flies 100 kts to the objective with an external load and 150 kts back from the objective, for an average trip speed of approximately 125 kts. For a Sea Base-to-objective radius of 100 nm:

MV-22 time per trip = ((2*100 nm)/(170 kts)) + 0.3 hr = 1.5 hr

CH-53X time per trip = ((2*100 nm)/(125kts)) + 0.3 hr = 1.9 ≈ 2.0 hr

In a single 12-hr period, each MV-22 could fly a maximum of 8 trips. Assume a 1 1/2-hr delay for refuel/crew switch/deck delays, the maximum number of MV-22 trips per 12-hr shift is reduced to 7.

In a single 12-hr period, each CH-53X could fly a maximum of 6 trips. Assume a 2-hr delay for refuel/crew switch/deck delays, the maximum number of CH-53X trips per 12-hr shift is reduced to 5.

Based strictly on external payload capacity, and given that the CH-53X carries nearly three times the external payload of the MV-22 at a 100 NM range, Figure 6-7 shows combinations of aircraft are capable of carrying three-quarters DOS in 12 hrs:

# CH-53	Max # Trips	# Trips short	# MV-22 trips req'd	# MV-22's req'd
10	50			
9	45	1	3	**1**
8	40	6	18	**3**
7	35	11	33	**5**
6	30	16	48	**7**
5	25	21	63	**9**
4	20	26	78	**12**
3	15	31	93	**14**
2	10	36	108	**16**
1	5	41	123	**18**
0	0	46	138	**20**

Figure 6-7: Air Connector Combinations for Sustainment.

6.7.1 Connector System Reliability Estimate

Based on the requirements analysis above, the air connector system is modeled as ten parallel paths as shown in Figure 6-8.

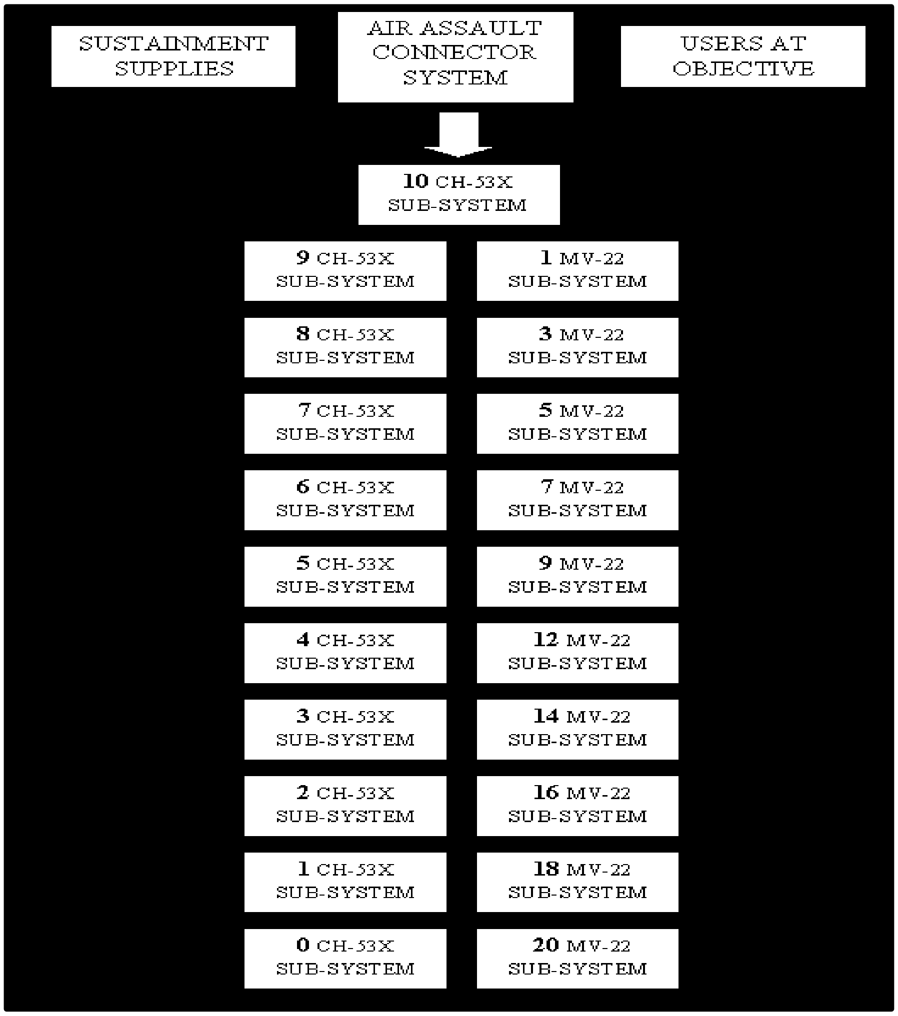


Figure 6-8: Air Assault Connector Reliability Block Diagram (one 12-hr day).

Each subsystem's reliability block is calculated as a *k*-of-*n* system using Eqn 6-3. The reliability of each individual path is calculated by multiplying the probability of k_1 CH-53s with the probability of having at least k_2 MV-22s. k_1 corresponds to the CH-53 value in Figure 6-8 and k_2 corresponds to the MV-22 value. The total reliability becomes the sum of the 11 paths, which equals 0.99.

6.7.2 Connector System Maintainability

The MTBF value is estimated using Eqn 6-5. For the purposes of this analysis, a failure means anything that renders an aircraft nonmission capable ("down").

For the CH-53X, assume the following expected values:[196]

MTTR = 16 hrs   MLOG = 1 hr.

Inserting these values into Eqn 6-5 yields an MTBF = 40 hrs. Using Eqn 6-1, with a mission time of 12 hrs and an MTBF of 40 hrs, the individual CH-53X reliability is estimated to be 0.74. Thus, there is approximately a 74% chance of a single CH-53X not failing in a 12-hr fly day.

For the MV-22, assume the following expected values:[197]

MTTR = 12 hrs   MLOG = 1 hr.

Inserting these values into Eqn 6-5 yields MTBF = 52 hrs. Using Eqn 6-1, with a mission time of 12 hrs and an MTBF of 52 hrs, the individual MV-22 reliability is estimated to be 0.80. Thus, there is approximately an 80% chance of a single MV-22 not failing in a 12-hr fly day.

6.7.3 Connector System Availability

A prototype CH-53X is not yet fielded, thus no actual data is available. Assume the CH-53X is a CH-53E Super Stallion basic airframe with new 6150 shaft horse-power engines (like the Rolls-Royce AE-1170C), the higher-rated transmissions, and the associated airframe modifications, including the improved 3-point lift system.[198] This analysis assumes that the CH-53X availability in 2015 will be similar to that of the CH-53X today. A Marine Corps Concept Development Command (MCCDC) slide that depicts assault aircraft for the future MEB[199] indicates that 6 of 20 will be unavailable:

unavailability = 6/20 = 0.3

availability = 1-(unavailability) = 1 - 0.3 = 0.7

[196] A "reasonable estimate" based on the expert opinion of three field-grade Naval Aviators and two Aviation Limited Duty Officers.
[197] A "reasonable estimate" based on the expert opinion of three field-grade Naval Aviators and two Aviation Limited Duty Officers.
[198] Helms, Douglas W., "A Bigger, Better Giant," Rotor & Wing (http://defensedaily.com), 26 September 2004.
[199] MCCDC, "Marine Experimental Brigade," briefing slide, 2004.

As of this writing, actual MV-22 availability/reliability data is not publicly available. A MCCDC slide depicting the assault aircraft for the future MEB indicates 9 of 47 MV-22s unavailable.[200]

unavailability = 9/47 = 0.2

availability = 1-(unavailability) = 1 - 0.2 = 0.8

6.8 Sustainment Phase System Reliability Estimate

The sustainment phase system reliability estimate is computed from the estimated reliability of the blocks in Figure 6-1. The SEA-6 functional teams generate the estimates for the system reliability of their respective boxes in Figure 6-1. Because all of the blocks are required to function together, the overall system is a series system whose reliability is calculated in Eqn 6-6 for a mission time of 720 hrs (30 days).

[Eqn 6-6]
$$R(t)_{BLA} = R(t)_{C2} * R(t)_{I\&S} * R(t)_{XFER1} * R(t)_{TOR} * R(t)_{XFER2}$$
$$R(t)_{BLA} = 0.99 * 0.86 * 0.78 * 0.99 * 0.78 \approx \mathbf{0.5}$$

6.8.1 2015 Baseline Reliability Importance

Reliability importance analysis identifies where in Figure 6-1 a small change in subsystem reliability will have the greatest effect on total system reliability. From Eqn 6-6, take the partial derivative of R_{BLA} and the reliability of the 2015 BLA sustainment system, with respect to each of the five functional blocks, to determine which functional area results in the highest reliability improvement.

$$\frac{\partial R(t)_{BLA}}{\partial R(t)_{C2}} = 0.5 \quad \frac{\partial R(t)_{BLA}}{\partial R(t)_{I\&S}} = 0.6 \quad \frac{\partial R(t)_{BLA}}{\partial R(t)_{XFER1}} = 0.7 \quad \frac{\partial R(t)_{BLA}}{\partial R(t)_{TOR}} = 0.5 \quad \frac{\partial R(t)_{BLA}}{\partial R(t)_{XFER2}} = 0.7$$

Based on these calculations, the sustainment phase system reliability will improve the most by improving the reliability of the transfer system (the block with the highest partial derivative value).

[200] Ibid.

6.9 Summary

The reliability analysis tells us that the 2015 BLA should be able to perform the required logistics policy of carrying 1 1/2 days' worth of supplies to the objective per day. Additionally, the increase in reliability of the transfer system (loading between platforms) will yield the greatest increase in total system reliability. This translates to better performance and greater dependability of the system. However, the relatively low overall system reliability estimate (0.5) does not mean that you cannot perform within the desired logistics policy. The current assumed system of systems configuration achieves the desired system availability (0.67).

When more system data is available, the SEABASE-6 model provides a useful tool to reevaluate system performance. Each assumed distribution for system modeling could be verified or changed as user-defined inputs that can generate system performance at both the Sea Base and the objective. A more detailed reliability analysis for the Landing Craft, Air Cushion (LCAC) is presented in Chapter 11, Section 7. SEA-6 recommends this analysis continue for other system components.

7. 2015 BASELINE ARCHITECTURE COST ESTIMATION ANALYSIS

7.1 Overview

This chapter documents the various steps taken to provide cost estimates of the 2015 Baseline Architecture (2015 BLA), to include:

- Defining Cost Estimation and Analysis.
- SEA-6 cost estimation goals.
- Constraints and assumptions.
- Cost estimation methodology.
- The 2015 BLA cost estimation.
- Cost estimation of each baseline architecture component.

Performing Cost Estimation and Analysis is intended to provide insight to the decision-maker regarding the expected costs associated with the logistical component of the Sea Base concept. In addition to decision-maker insights, the cost estimation of the 2015 BLA is used to perform comparative studies against project alternatives.

For the cost estimating process, several assumptions that apply to the overall estimation are necessary. Each 2015 BLA element requires specific assumptions. High-level assumptions include:

- Open source costing data is assumed to be complete and accurate.
- Open source per unit cost data is assumed to include all program acquisition costs and are average procurement unit costs (APUC).
- Disposal costs are minimal and do not adversely impact cost estimates.
- Cost data in high-level governmental budgetary documentation is assumed to be highly accurate and includes all costs.

7.2 Cost Estimating and Analysis

The Defense Acquisition University defines Cost Estimating and Analysis as a formal discipline for predicting the future cost of systems, subsystems, and components based on historical data[201] and considers it a vital aspect of the Defense Acquisition System.

The DoD Directive 5000 series governs the Defense Acquisition System. One directive, DoD Directive 5000.1, states the primary objective of Defense Acquisition is to acquire quality products that satisfy user needs with measurable improvement to mission capability and operational support, in a timely manner, and at a fair and reasonable price.[202]

Performing Cost Estimating and Analysis serves two purposes in meeting its objective of ensuring proper pricing. The Milestone Decision Authority (MDA) uses cost estimates during the acquisition phase at each acquisition program milestone and decision review to assess whether the future system cost is affordable and consistent with the DoD's overall long-range investment and force structure plans.[203] Cost estimates are also used by each service component to form the annual budget requests to Congress. Without performing cost estimates, the ability to meet the objective of ensuring fair and reasonable pricing of future systems and ensuring budgetary requests are approved becomes constricted.

When performing cost estimates, DoD Directive 5000.1 states costing data should include all the costs associated with ownership, referred to as total ownership cost

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[201] Defense Acquisition University, "Cost Estimating," para. 1 [data online] (17 February 2004 [cited 15 September 2004]); available from World Wide Web @ http://acc.dau.mil/simplify/ev.php?ID=1437_201&ID2=DO_TOPIC.

[202] Department of Defense, DoD Directive 5000.1 – The Defense Acquisition System, para. 4.2 [instruction online] (12 May 2003 [cited 01 October 2004]); available from World Wide Wed @ http://akss.dau.mil/darc/darc.html.

[203] Department of Defense, DoD Direective 5000.2 – Operation of the Defense Acquisition System, para. 3.1 [instruction online] (12 May 2003 [cited 01 October 2004]); available from World Wide Web @ http://akss.dau.mil/darc/darc.html.

(TOC).[204] A defense system's total ownership cost (TOC) is equal to the system's life cycle cost (LCC).[205] For purposes of cost estimating, the LCC includes four primary cost categories (research and development (R & D), procurement, operating and support costs (O & S) and disposal) and seven cost elements,[206] shown in Figure 7-1. Definitions for each cost element include:[207]

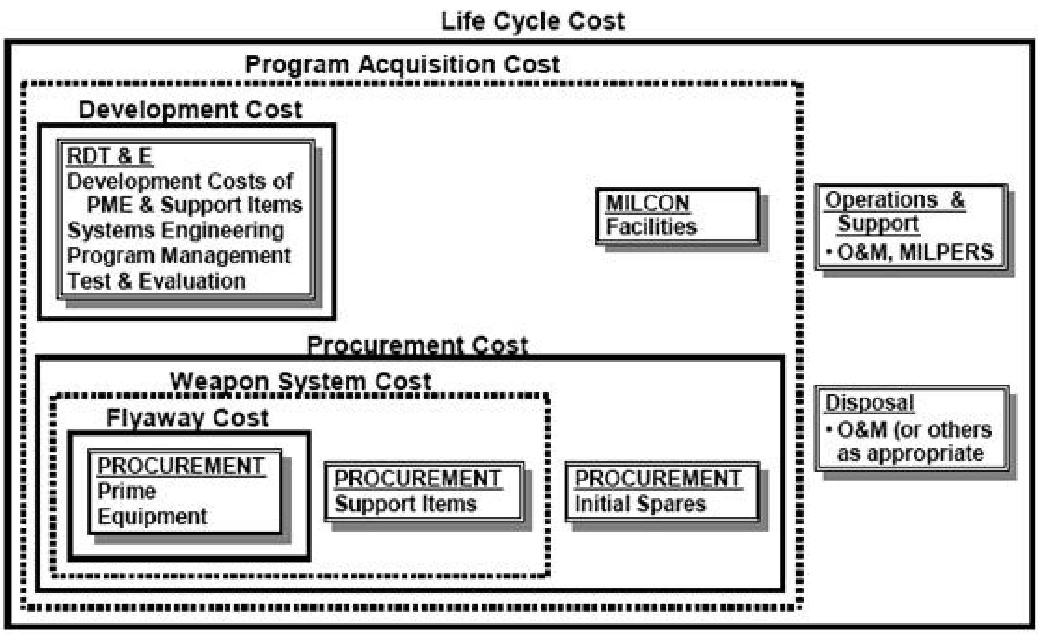

Figure 7-1: Life Cycle Cost Composition.208

- Development Costs – The costs primarily associated with R & D efforts including the development of a new or improved capability to the point where it is appropriate for operational use. Development costs are those incurred from program initiation at the conceptual phase through the end

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[204] Department of Defense, DoD Directive 5000.1 – The Defense Acquisition System, para. E1.4 [instruction online] (12 May 2003 [cited 01 October 2004]); available from World Wide Web @ http://akss.dau.mil/darc/darc.html.

[205]Defense Acquisition University, Glossary: Defense Acquisition Acronyms and Terms, p. B-144 [instruction online] (September 2003 [cited 02 October 2004]); available from World Wide Web @ http://www.dau.mil/pubs/glossary/preface.asp.

[206] Department of Defense, DoD Directive 5000.4M – Cost Analysis Guidance and Procedures, para. 3.3.3.1 [instruction online] (December 1992 [cited 30 September 2004]); available from World Wide Web @ http://www.ncca.navy.mil/resources/guidance.cfm.

[207] Ibid.

[208] Jim Gates, "Introduction to Cost Analysis," p. 4 [teaching notes online] (April 2004 [cited 01 October 2004]); available from World Wide Web @ http://acc.dau.mil/simplify/ev.php?ID=19844_201&ID2=DO_TOPIC.

of engineering and manufacturing development. Examples include the cost of prime mission equipment, program management, training, specialized equipment, instrumentation, testing, feasibility studies, modeling, tradeoff analyses, engineering designs, prototype assembly, and facilities required to support R & D.

- Procurement Costs – The sum of all the associated procurement costs for prime mission equipment, weapon system costs, support items, initial spare parts, repair parts, engineering changes, preplanned product improvement, transportation costs, and outfitting/post delivery costs (for Navy shipbuilding programs).
- O & S Costs– All direct and indirect costs incurred in using the delivered system that includes the cost of personnel, equipment, maintenance, supplies, software, and services (including contract support) associated with operating, modifying, maintaining, supplying, training, and supporting the defense system.
- Disposal Costs – The costs associated with deactivating or disposing of a materiel system at the end of its useful life. Disposing of a materiel system can result in additional costs or a salvage value depending on the disposition. Disposal costs are normally insignificant compared to the total life cycle cost.

Figure 7-2 is a graphical representation of the four primary cost categories. Throughout the life cycle, cost is historically incurred at various percentages. For development costs (R & D), the average total cost is approximately 5%-15% of the total life cycle cost. The total associated procurement costs comprise approximately 10%-20% of the total. The most prominent cost incurred during the life cycle is the O & S cost, which constitutes 55%-80%. This cost is directly proportional to the operational life of a given system. The least significant cost incurred during the life cycle is the disposal cost, which generally equals approximately less than 5% of the total life cycle cost. Disposal costs are often considered minimal and are included in the O & S cost category by

military components' cost analysis agencies.[209] There are cases where disposal costs have a greater cost value, such as with the disposal of nuclear waste (or other hazardous materials) and missile propellants.

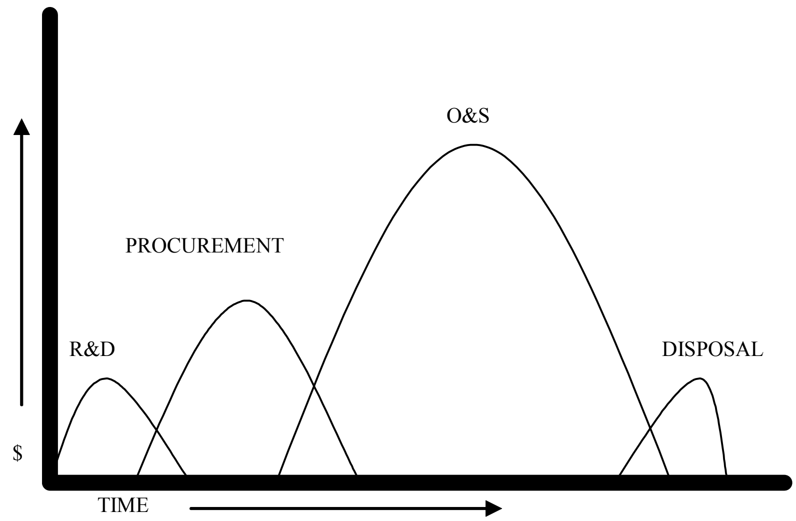

Figure 7-2: Life Cycle Cost Categories.[210]

7.3 Cost Estimating Methodology

DoD Directive 5000.4-M "Cost Analysis Guidance and Procedures" and Chapter 12 of the Acquisition Logistics Guide (ALG) provides a standard cost estimating process that is the basis for the cost estimate of the SEA-6 2015 BLA. Figure 7-3 is a graphical representation of the process.

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[209] Defense Systems Management College, Acquisition Logistics Guide, para. 12.2.1.1 [instruction online] (December 1997 [cited 01 October 2004]); available from World Wide Web @ http://www.dau.mil/pubs/gdbks/acqulogguide.asp.
[210] Ibid.

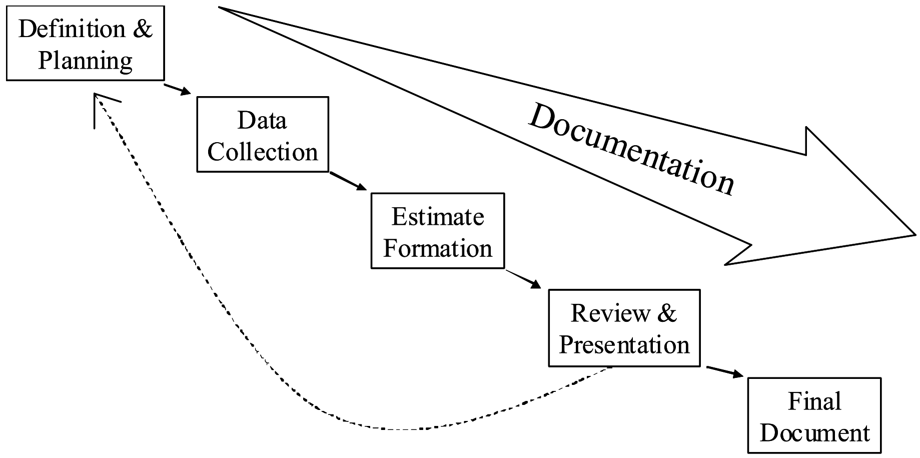

Figure 7-3: Cost Estimating Process.[211]

7.3.1 Definition and Planning

The definition and planning phase contains several key aspects that are addressed throughout the SEA-6 2015 BLA cost estimate to include:

- Knowing the purpose of the estimate.
- Defining the system requiring cost estimation.
- Establishing ground rules, constraints, and assumptions.
- Selecting the estimating approach.

Cost Estimation and Analysis has two primary purposes: to ensure affordability and for budget formulation. Two additional purposes are generated to fully capitalize on the usefulness of cost estimation. The first of these additional purposes is to provide insights for decision makers regarding the costs associated with the 2015 BLA. The second is to use the quantitative data derived from the 2015 BLA in comparative studies against alternative architectures during the FSA phase.

A generic, indirect Cost Analysis Requirements Description (CARD)[212] of the 2015 BLA is used to determine what systems require cost estimates. Prior to

[211] Mislick, Gregory, LtCol, USMC, "Chapter 1: Cost Estimation Introduction and Overview," slides 1-12 [online brief] (August 2004 [cited 01 September 2004]); available from World Wide Web @ http://diana.gl.nps.navy.mil/~gkmislic/oa4702.

commencing the cost estimation, abstract ground rules, identifiable constraints and applicable assumptions are required. The high-level constraints and assumptions identified previously are used, along with the following ground rules.

- All costs are generated using Fiscal Year (FY) 2004 as the base year.
- All costs are normalized to FY15.
- All cost data are compared between two sources, when available, for verification.
- Excel Spreadsheets are the primary modeling tool.

A key component of the definition and planning phase of the cost estimating process is the selection of the estimating approach. DoD cost agencies primarily use four specific cost estimating approaches:[213]

- Analogy Method.
- Parametric Method.
- Engineering Method.
- Extrapolation from Actual Costs Method.

The analogy and extrapolation from actual costs methods are the two methods used to estimate the cost for the 2015 BLA. Brief descriptions are provided for understanding of each method.[214]

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[212] Department of Defense, DoD Directive 5000.4M – Cost Analysis Guidance and Procedures, para. 3.3.3.1 [instruction online] (December 1992 [cited 30 September 2004]); available from World Wide Web @ http://www.ncca.navy.mil/resources/guidance.cfm.
[213] Defense Systems Management College, Acquisition Logistics Guide, para. 12.4 [instruction online] (December 1997 [cited 01 October 2004]); available from World Wide Web @ http://www.dau.mil/pubs/gdbks/acqulogguide.asp. and Jim Gates, "Introduction to Cost Analysis," pp. 3-5 [teaching notes online] (April 2004 [cited 01 October 2004]); available from World Wide Web @ http://acc.dau.mil/simplify/ev.php?ID=19844_201&ID2=DO_TOPIC.
[214] Jim Gates, "Introduction to Cost Analysis," pp. 3-5 [teaching notes online] (April 2004 [cited 01 October 2004]); available from World Wide Web @ http://acc.dau.mil/simplify/ev.php?ID=19844_201&ID2=DO_TOPIC.

7.3.2 Analogy Method

The analogy method compares a new or future system with one or more similar existing systems by conducting subjective evaluations between the historical data and the anticipated future system. To compare the two systems, a variety of factors are developed to assist in the estimation to include cost, complexity, miniaturization, production improvement or other useful injects.

7.3.3 Extrapolation from Actual Costs Method

The extrapolation from actual costs method uses actual cost experience on prototype units, early engineering development hardware and early production hardware for the system production to predict future costs. When available, the use of actual costs is the preferred method and is used to the maximum extent possible. This method is conducted in conjunction with the analogy approach when actual costs are available for a similar system or variant.

7.3.4 Data Collection

The next step in the cost estimating process is the data collection. For the SEA-6 project, a variety of open source references are used to perform the 2015 BLA cost estimates. To ensure the validity of unit costs, two references are used if available. If the two references are inconsistent, subjective evaluations are conducted to decide which reference to use. When feasible, cost data is taken from actual contract costs that include all costs for R & D and procurement. Since one of the primary functions of a cost estimate is to provide input for budget formulations, the FY05 Presidential Budget[215] is utilized for cost data based on the assumption that highly accurate cost estimates are used to generate the Presidential Budget. The majority of the cost data is from the following organizations or reports.

[215] Department of Defense, Defense Budget Materials: FY2005 Budget [database online] (10 March 2004 [cited 18 October 2004]); available from World Wide Web @ http://www.dod.mil/comptroller/defbudget/fy2005/index.html.

- FY05 Budget of the Department of the Navy/Army/Air Force.
- Jane's Information Group.
- U.S. Air Force Fact Sheets.
- Global Security.
- Department of Defense.
- Federation of American Scientists (FAS).
- Naval Air Warfare Center (NAVAIR).
- Naval Sea Systems Command (NAVSEA).
- U.S. Navy Fact Files.
- United States Marine Corps (USMC) Fact Files.
- Selected Acquisition Reports (SAR).
- Center for Naval Analysis (CNA).
- Maritime Business Strategies.

For O & S costs, the primary data source is the Navy Visibility and Management of Operating and Support Costs (VAMOSC) management information system,[216] which is maintained by the Navy Cost Analysis Division (NCAD). The VAMOSC management information system collects and reports U.S. Navy and U.S. Marine Corps historical weapon system O & S costs. It provides the direct O & S costs of weapon systems, some linked indirect costs, such as ship depot overhead, and related noncost information such as flying hour metrics, steaming hrs, age of aircraft, and more. The program recently added the Personnel database, which contains all Active Duty Navy and USMC personnel costs and attribute data. In addition to the VAMOSC database, NCAD

[216] VAMOSC is a restricted access system. Access permission must to granted by the NCAD. The VAMOSC system is located at http://www.navyvamosc.com/.

provides the current inflation rates and indices that are used in the normalization of cost data to FY04 and FY15.[217]

7.3.5 Estimate Formulation

With historical cost data in hand, the formulation of the 2015 BLA can begin. For each baseline component, an estimating approach is selected and applied. The costing base year, the reference period that determines a fixed price level for comparison in economic escalation calculation and cost estimations, is set for the FY04. All costs are normalized to FY04 to provide consistent cost data. From the normalized cost data, costs are projected to FY15 to establish the cost of the future baseline component.

For the cost estimate, the APUC is calculated for each asset of the 2015 BLA. The APUC is calculated by dividing the total procurement cost by the number of assets that were procured or planned for procurement.

For the complete development of the LCC, O & S costs are retrieved from the VAMOSC database. The historical O & S costs are used to estimate future cost for current and future systems. For future O & S cost predictions, an average annual increase is calculated from the available historic O & S cost data. The average annual increase is applied to the years FY04 to FY15. For future systems, an analogy approach utilizing a cost factor is applied to calculate O & S costs.

7.3.6 Review and Presentation

Throughout the course of the cost estimation, periodic reviews are conducted to ensure accuracy and completeness. All cost estimating data is presented to the team's NPS faculty cost advisor, LtCol Gregory Mislick (USMC),[218] for review and clarification.

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217 Inflation indices can be obtained from the Navy Cost Analysis Division (NCAD) at http://www.ncca.navy.mil/services/inflation.cfm.

218 LtCol Mislick is the Associate Dean for the Graduate School of Operational and Information Sciences at the Naval Postgraduate School and is an instructor for the course OA4702: Cost Estimation of DoD Weapons Systems.

7.4 2015 Baseline Architecture

The 2015 BLA for a single Maritime Prepositioning Force Future (MPF(F)) squadron [Chapter 5] consists of 8 ships, 1 Combat Logistics Force (CLF) ship, 26 surface connectors, 79 assault air connectors, and 70 nonconnector air assets. Specific platforms and quantities include:

- 8 Maritime Prepositioning Force, Future (MPF(F)) (unconstrained-size, Full ACE, distributed-capability variant) ships;[219]
- 1 Fast Combat Support Ship (T-AOE);
- 48 MV-22 Ospreys;
- 20 CH-53X Super Stallions;
- 12 SH-60R Seahawks;
- 18 AH-1Z Super Cobras;
- 36 F-35 Joint Strike Fighters (JSFs);
- 6 Vertical Take-off Unmanned Aerial Vehicles (VTUAVs);
- 9 UH-1Y Iroquois;
- 24 Landing Craft, Air Cushion (LCACs); and
- 2 Landing Craft Utility, Replacement (LCU(Rs)).

7.5 Cost Estimation

Table 7-1 is a summary of the cost estimate for the 2015 BLA. The calculations used to determine the cost estimation are located in Appendix C. Dollar figures are shown in FY04 to indicate the cost value in today's dollars. The FY2004 dollar values are normalized using the inflation indices provided by the Naval Cost Analysis Division (NCAD) to account for inflation and the time value of money in order to show the anticipated cost of the 2015 BLA.

[219] Souders et al., p. 33.

Platform	Quantity	Life Cycle Cost (BY04$)	Life Cycle Cost (FY15$)
MPF(F)	8	$16,004,120,970	$19,588,611,469
T-AOE	1	$1,552,400,599	$1,900,128,650
MV-22	48	$7,741,104,368	$9,475,009,238
CH-53X	20	$2,825,866,361	$3,458,830,717
SH-60R	12	$1,095,440,391	$1,340,807,207
AH-1Z	18	$1,083,348,674	$1,326,008,973
JSF (F-35)	36	$5,397,219,681	$6,606,115,954
UAV	6	$18,784,685	$22,991,946
UH-1Y	9	$495,033,217	$605,913,963
LCAC	24	$1,078,807,272	$1,320,430,940
LCU(X)	2	$34,305,263	$41,988,715
Baseline Total Cost		$37,326,431,481	$45,686,837,773

Table 7-1: 2015 Baseline Architecture Cost Summary.

As indicated in Table 7-1, if the 2015 BLA were assembled in 2004, it would cost approximately $37.3 billion. When inflation indices are applied, the cost for the 2015 BLA grows to approximately $45.7 billion.

The measures taken to calculate the 2015 BLA component's cost follows. Each section addresses the cost data reference, methodologies, the cost estimating approach used, specific assumptions for each particular component, and O & S costs. Section 7.3.5 describes the process for normalizing all cost data to the appropriate years.

7.5.1 Maritime Prepositioning Force, Future

All MPF(F) cost data is from the MPF(F) study[220] conducted by the CNA. CNA, with the assistance of NAVSEA and Military Sealift Command (MSC), developed a total ownership cost/life cycle cost for each of the MPF(F) alternatives addressed in the study. All costs are calculated based on a squadron size. Since the SEA-6 2015 BLA includes a larger MPF(F) squadron size (8 versus 6 vessels), extrapolation of the CNA cost data is necessary. For the 2015 BLA, the cost data from CNA is for the unconstrained, full Air Combat Element (ACE), distributed Sea Base variant as described in Chapter 5. Both CNA and the SEA-6 Cost Estimation Team make the following assumptions.

[220] Ibid., pp. 48-55.

- NAVSEA costs are accurate and appropriate (CNA, SEA-6).
- All follow-on ships maintain the same acquisition cost with no learning curve improvements (CNA).
- MPF(F) vessels will have a 40-year life (CNA, SEA-6).
- Additional manning for Sea Base support would be approximately 2,118 personnel (CNA).
- The lead ship and first follow-on ship are equipped with the Marine Expeditionary Brigade (MEB) C2 suite (SEA-6).
- All MPF(F) ships are JSF capable (SEA-6).
- O & S costs include the cost of the Naval Support Element for the Sea Base (SEA-6).
- The cost of additional ships maintain the same cost as outlined in the CNA study (SEA-6).
- O & S costs are the same for each MPF(F) (SEA-6).
- All R&D and production costs are included in the APUC (SEA-6).
- Production of the MPF(F) ships (8) will be completed by 2012, with a production schedule of 1 each in 2008 and 2009, 2 each in 2010 and 2011, and 2 in 2012 (SEA-6).
- The CNA/NAVSEA cost estimation is preformed using a analogy and parametric cost estimating approach (SEA-6).
- CNA cost data include annual inflation increases (SEA-6).

Figure 7-4 displays the cost data used to determine the acquisition cost of the eight unconstrained, full ACE, distributed Sea Base MPF(F) ships in the 2015 BLA.

Ship	Lead ship (FY'08 $M)	First follow ship (FY'09 $M)	Squadron acquisition (TY$B)
Mod-LMSR no seabase	$795	$630	$3.3
Clean sheet no seabase	$1,100	$775	$4.2
Constrained distributed R/W and T/R only	$1,690	$1,290	$7.4[a]
Clean sheet dense pack ships	$1,100	$775	
R/W and T/R constrained, distributed sea base	$1,690	$1,290	$11.2
Constrained full ACE, distributed sea base	$1,790	$1,360	$11.8
Unconstrained, full ACE, distributed sea base	$2,300	$1,730	$11.6
Family, specialized logistics ship	$1,060	$780	
Family specialized RO/RO & personnel ship	$1,600	$1,160	$11.0[b]
Family specialized air & command ship	$1,870	$1,420	----------------------
Family, specialized unconstrained logistics and RO/RO ship	$1,620	$1,180	$10.4[c]
Family, specialized constrained logistics and RO/RO ship	$1,420	$1,030	$11.8[d]
AFSB/ESS ship	$1,460	$1,110	N/A

a. The small size seabase has 3 constrained seabase ships and 3 densely packed ships
b. The squadron of three types of specialized ships has 2 logistics ships, 3 RO/RO ships, and 3 Aviation ships.
c. The squadron of two unconstrained types of specialized ships has 4 Logistics & RO/RO ships, and 3 Aviation ships.
d. The constrained squadron of two types of specialized ships has 3 aviation ships and constrained logistics and RO/RO ships.

Figure 7-4: CNA Ship and Squadron Acquisition Costs.[221]

From Figure 7-4, CNA is estimating the acquisition cost for the lead ship to be $2,300 million (FY08$) with all follow-on ships maintaining a fixed cost of $1,730 million (FY$). For the SEA-6 cost estimate, an additional cost for the MEB Command and Control (C2) suite ($40 million) is included for the lead and first follow-on ship. In addition, another cost is included to provide each MPF(F) with JSF handling capability ($95 million). From the total acquisition cost per ship, the cost data is normalized, based on the assumed production schedule.

Figure 7-5 displays O &S cost data from the CNA study that is the basis for the O & S costs in the 2015 BLA cost estimation. Per the CNA study, O & S costs for a 6-ship MPF(F) squadron operating at a Sea Base increases the TOC/LCC cost by $14.4 billion.

[221] Ibid., p. 49.

Ship	New Cargo ops manning	New Aviation ops manning	Existing NSE manning	Total Squadron manning required	40-year squadron manning add'l costs ($B)	Squadron seabasing TOC ($B)
mod-LMSR no sea base	0	0	1,100	1,100	0	$8.8
Clean sheet no sea base	0	0	1,100	1,100	0	$10.2
Small size sea base squadron[a]	118	170	200	1,064	$1.4	$16.1
R/W and T/R constrained, distributed seabase (8 per squadron)	118	170	376	2,680	$3.7	$25.3
Constrained full ACE, distributed seabase (8 per squadron)	118	170	320	2,624	$3.7	$26.7
Unconstrained, full ACE, distributed seabase (6 per squadron)	118	170	390	2,118	$2.8	$26.0
Family, specialized logistics ship (2 per squadron)	118	25				
Family specialized RO/RO & pax ship (3 per squadron)	80	25	390	1,741[b]	$2.7[b]	$24.4[b]
Family specialized air & command ship (3 per squadron)	80	170				
Specialized unconstrained logistics and RO/RO ship (4 per squadron)	118	25	376	1,698[c]	$2.7[c]	$23.8[c]
Specialized constrained logistics and RO/RO ship (6 per squadron)	118	25	390	1,998[d]	$3.5[d]	$28.4[d]
AFSB/ESS ship (1 ship)	118	170	0	288	$0.4	$3.4 per ship

a. The small size seabase has 3 constrained, distributed capability R/W and T/R sea base ships and 3 clean sheet dense pack ships
b. The squadron of three types of specialized ships has 2 logistics ships, 3 RO/RO ships, and 3 Aviation ships.
c. The unconstrained squadron of two types of specialized ships has 4 Logistics & RO/RO ships, and 3 Aviation ships.
d. The constrained squadron of two types of specialized ships has 6 constrained logistics RO/RO ships, and 3 aviation ships.

Figure 7-5: CNA Total Ownership Cost Data.[222]

To calculate the O & S costs for the 2015 BLA, the CAN-estimated O & S costs are assumed to be equally distributed between the 6 ships within the squadron and then distributed on a per year basis, which results in allocating $60 million per year to each ship. To calculate the total O & S cost up to 2015 for each of the 8 MPF(F) ships in the 2015 BLA, all costs are normalized for each year up to 2015, based on the assumed production schedule for each ship. For the SEA-6 MPF(F) squadron of 8 ships, it is assumed each additional ship will require the same level of O & S costs as provided by the CNA study.

[222] Ibid., p. 54.

7.5.2 Fast Combat Support Ship

To support the MPF(F) ships, one Fast Combat Support Ship (T-AOE) is included in the 2015 BLA. The current U.S. inventory contains four T-AOE ships that are expected to continue service beyond 2015. The cost estimate for the T-AOE uses the extrapolation from actual cost estimating approach for each component of the LCC.

Acquisition costing data for each T-AOE is from the Maritime Business Strategies,[223] a strategic management-consulting firm for the maritime industry. Since it is unknown which T-AOE will be assigned to support the MPF(F) in 2015, an APUC, based on the procurement cost of each ship, is used. To calculate the APUC, the procurement cost of each ship is normalized to the base year (2004) from which the APUC is determined to establish the procurement cost of the T-AOE used in the LCC estimate.

O & S costs are from the VAMOSC database. For continuity, the average O & S cost for the T-AOE-6 class is used. To obtain average ship class data, the VAMOSC "Ship Class Average Query – All Elements (FY04$)" option for data results is utilized to capture all O & S costs across all ships within the class. O & S costs are available for the past nine years. To calculate future year O & S costs, the percentage change between each year is calculated and is averaged. This averaged annual percentage increase is applied to the average annual O & S cost to calculate expected future O & S costs. The actual historic and expected O & S costs are summed to determine the O & S component of the life cycle cost.

7.5.3 MV-22 Osprey

For the 2015 BLA, 48 MV-22s are included. For the SEA-6 cost estimation, the APUC is from the Department of the Navy's FY05 President's Budget.[224] The budgetary

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[223] Tim Colton, "U.S. Government Shipbuilding – Auxiliary Ships," [online database] (29 October 2004 [cited 18 October 2004]); available from World Wide Web @ http://www.coltoncompany.com/shipbldg/ussbldrs/postwwii/government/auxiliaries.

[224] Department of Defense, Defense Budget Materials: FY2005 Budget [database online] (10 March 2004 [cited 18 October 2004]); available from World Wide Web @ http://www.dod.mil/comptroller/defbudget/fy2005/index.html.

cost data are a function of the total program cost and the number of expected procurements.

For the O & S cost component of the life cycle cost, data is from the VAMOSC database. The database contains four years of O & S costs for the MV-22. However, with the operational problems and mishaps, the historical O & S costs do not appear to be a true representation of the future costs. There is a 43% average annual increase in O & S costs over the 4 years of data. Yet, the cost data is based only on 7 aircraft. To predict a more reasonable estimate of the future O & S cost for each MV-22, an analogy cost estimating approach with a cost factor is utilized. Using only 3 of the 4 years of O & S cost data, an average per unit O & S cost is calculated. Instead of applying a 43% annual increase, the annual percentage increase of 4 other aircraft (AV-8B, EA-6B, F-14D, and F/A-18E) is applied. On average, each of the 4 aircraft types demonstrated an annual increase of 12% per year. This factor is applied to the MV-22's average O & S cost to predict future O & S costs out to 2015.

7.5.4 CH-53X Super Stallion

There are 20 CH-53Xs in the 2015 BLA. The CH-53X is a future upgrade of the existing CH-53E. For the cost estimation, the CH-53X cost is based on the cost of the CH-53E. The acquisition and procurement cost for the aircraft is from Jane's Information Group.[225] This CH-53E cost data is assumed to be an APUC.

To determine the O & S cost component for the life cycle cost, seven years of O & S cost data are available from the VAMOSC database. The average annual O & S cost increase percentage is calculated from the historical data and applied to future years. For the LCC, O & S cost data was included from 1997 to 2015. Since the CH-53X is an upgraded CH-53E, the cost of the upgrade per aircraft is classified as O & S. The upgrade's cost is included in the O & S for FY11. Along with improving the capability of the current CH-53E, the CH-53X is expected to require 25% less O & S costs. A 25% decrease is included in the annual O&S costs per aircraft for the years FY12 to FY15.

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[225] Jane's Information Group, "Sikorsky CH-53X" [database online] (21 October 2002 [cited 18 October 2004]); available from World Wide Web @ http://www4.janes.com/.

7.5.5 SH-60R Seahawk

The SH-60R is the scheduled replacement for the SH-60B and SH-60F. The SH-60R has recently entered the production phase and cost data are available in the FY05 President's Budget.[226]

To determine the O & S cost of the SH-60R, an analogy cost estimating approach with a cost factor is utilized. Since the SH-60R is a planned replacement for the SH-60B, historical O & S costs for the SH-60B are used to predict the future costs. The VAMOSC database contains seven years' worth of SH-60B O & S cost data. To calculate future year O & S costs, the percentage change between each historic year is calculated and averaged. This averaged annual percentage change is applied to the average annual SH-60B O & S cost to calculate the expected O & S costs for the SH-60R.

7.5.6 AH-1Z Super Cobra

The AH-1Z is a planned upgrade to the AH-1W. The program for the AH-1Z includes upgrading certain AH-1Ws to AH-1Zs with new production comprising the majority of the program. Cost estimation data for the AH-1Z is located in the FY05 President's Budget.[227] For the cost estimation, it is assumed all baseline AH-1Zs were the newly manufactured airframes.

Since the AH-1Z includes upgraded AH-1Ws, an analogy cost estimating approach is used to compute the cost estimation for the AH-1Z based on historical AH-1W O & S cost data. The VAMOSC database contains seven years of historical data that is used to determine the future O & S costs of the AH-1Z.

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[226] Department of Defense, Defense Budget Materials: FY2005 Budget [database online] (10 March 2004 [cited 18 October 2004]); available from World Wide Web @ http://www.dod.mil/comptroller/defbudget/fy2005/index.html.
[227] Ibid.

7.5.7 F-35 Joint Strike Fighter (JSF)

The 2015 BLA includes 36 JSFs. Costing data for future capabilities can be located in a Department of Defense SAR.[228] The costing data are provided as a total program cost with the number of expected procurements. An APUC is calculated to determine the cost of each unit.

The JSF is currently in the development phase and no actual O & S costs are available in the VAMOSC database. To determine the future O & S costs of the JSF, an analogy cost estimating approach is implemented with a cost factor that uses the F/A-18F as the similar aircraft. The average annual O & S costs for the F/A-18F is calculated from historical data. It is assumed the JSF will require 5% more O & S cost per year than the F/A-18E. Based on this assumption, a .05 cost factor is applied to the F/A-18F annual O & S cost. The annual increase for the F/A-18F is calculated and applied to each future year.

7.5.8 Vertical Take-off Unmanned Aerial Vehicles

Per the CNA MPF(F) study, it is expected that the MPF(F) squadron will operate with six VTUAVs when operating in a Sea Base environment.[229] To determine VTUAV cost during the 2015 time frame, the SEA-6 cost estimate is accomplished utilizing the RQ-8 Fire Scout VTUAV that is currently under development as an analogous system for the procurement costs.

Limited cost data is available for VTUAV's. For the Fire Scout, cost data being used is from the Under Secretary of Defense's Unmanned Aerial Vehicle (UAV) Planning Task Force report.[230]

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[228] Department of Defense, SAR Program Acquisition Cost Summary [report online] (30 September 2003 [cited 18 October 2004]); available from World Wide Web @ http://www.defenselink.mil/news/Nov2003/d20031118sar.

[229] Souders et al., p. 21.

[230] Department of Defense, Unmanned Aerial Vehicle Planning Task Force: The UAV Roadmap 2002 [report online] (25 October 2001 [cited 18 October 2004]); available from World Wide Web @ http://www.aviationnow.com/content/publication/awst/docs/exec_sum.pdf.

To determine the future O & S costs for the VTUAV, an analogy cost estimating approach using the United States Air Force's RQ-1 Predator UAV as an analogous system is performed. It is assumed that the RQ-8 will exhibit operating and support cost requirements similar to the RQ-1. To determine the O & S costs for the RQ-1, cost data from the FY05 President's Budget[231] for the RQ-8 is used.

7.5.9 UH-1Y Iroquois

The UH-1Y is a future capability that is intended to replace the UH-1N. The program is intended to convert selective UH-1Ns into UH-1Ys and to manufacture new airframes. For the SEA-6 cost estimation, it is assumed all aircraft included in the 2015 BLA are of the newly constructed variant.

Cost estimating data for the acquisition and procurement costs are located in the FY05 President's Budget.[232] The budget contains the total program cost, along with the APUC for the future UH-1Y.

Since the UH-1Y is the planned replacement for the UH-1N, the O & S cost data for the UH-1N is used to conduct an analogy cost estimating approach. The average annual O & S cost is calculated using data obtained from the VAMOSC database. A cost factor of .05 is applied to the annual O & S cost to predict future UH-1Y O & S costs. In addition to a 5% greater annual expected cost, the historic annual cost increase is determined for the UH-1N and applied to all future years.

7.5.10 Landing Craft, Air Cushion

As Chapter 5 outlines, SEA-6 assumes 24 LCACs are required in the 2015 BLA. Acquisition and procurement cost data is obtained from the Maritime Business

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[231] Department of Defense, Defense Budget Materials: FY2005 Budget [database online] (10 March 2004 [cited 18 October 2004]); available from World Wide Web @ http://www.dod.mil/comptroller/defbudget/fy2005/index.html.
[232] Ibid., para. 5.

Strategies.[233] From this open-source cost data, an extrapolation from actual costs is applied.

There are currently 91 LCACs in the U.S. Navy's inventory. Since it is unknown which of those 91 LCACs might be utilized in the 2015 BLA, an average unit cost is calculated for the cost estimation. Though it is uncertain if all acquisition and procurement costs are included in the open source data, it is assumed that all costs are captured in the data, based on the learning curve apparent in the cost data. To determine the average unit cost, the cost of each unit is normalized to the base year and then averaged.

LCAC O & S costs are not maintained separately by the VAMOSC database. Instead, O & S costs for the LCAC are included in O & S cost data for the platforms that operate them. The cost to operate or support the LCAC, however, is not distinguished. The LCAC inventory is currently undergoing a Service Life Extension Program (SLEP). SLEP costs are categorized as O & S costs and are the only O & S costs that can be included. For the SLEP, cost data is located in the FY05 President's Budget.[234] The budget reports the total program cost, as well as the per unit cost for the upgrades. The SLEP cost data are normalized and is included in the O & S costs for each LCAC.

7.5.11 Landing Craft Utility, Replacement

The LCU(R) is the intended replacement craft for the aging LCU. It is currently in the low rate initial production (LRIP) phase with 19 units planned for procurement. Cost data are found in the FY05 President's Budget.[235]Budget documentation contains all acquisition and procurement costs for each of the 19 future crafts.

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[233] Tim Colton, "U.S. Government Shipbuilding – Auxiliary Ships" [online database] (29 October 2004 [cited 18 October 2004]); available from World Wide Web @ http://www.coltoncompany.com/shipbldg/ussbldrs/postwwii/government/lcac.htm.
[234] Department of Defense, Defense Budget Materials: FY2005 Budget [database online] (10 March 2004 [cited 18 October 2004]); available from World Wide Web @ http://www.dod.mil/comptroller/defbudget/fy2005/index.html.
[235] Ibid., para. 1.

Since the LCU(R) is currently in the LRIP phase of production, no O & S cost data are available. It is not expected that the VAMOSC database will contain future O & S costs once the craft is implemented into the fleet.

7.6 Summary

As Table 7-1 indicates, the SEA-6 baseline architecture has an estimated total cost of $45.6 billion (FY15). Figure 7-6 is a graphical depiction of the percentage that each component contributes to the total cost. The data generated during the cost estimation of the 2015 BLA will be used during the Functional Solution Analysis (FSA) to compare the cost effectiveness of alternative compositions beyond 2015.

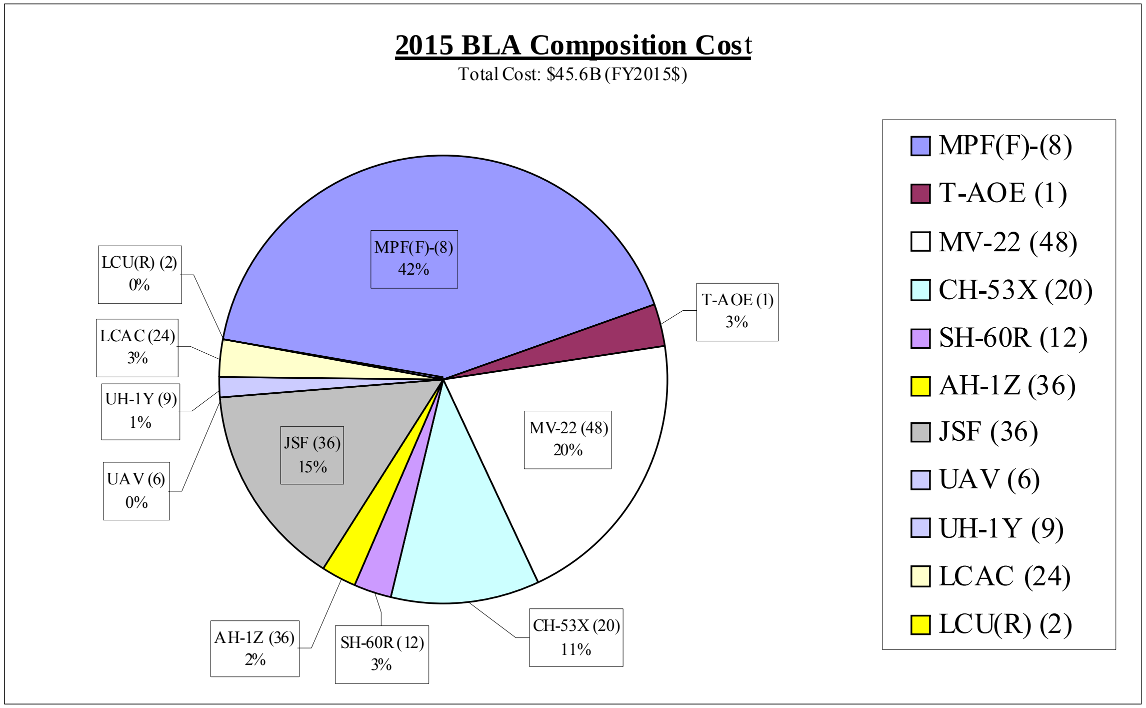

Figure 7-6: 2015 Baseline Architecture Cost Distribution.

8. Modeling and Simulation

8.1 Overview

A model is a simplified representation of a system intended to support understanding of the real system. Simulation is a model embedded in a computer program that moves defined entities from place to place, in time and space, according to rules that may be deterministic or stochastic. Modeling and simulation can be used collectively for developing a level of understanding of the interaction of the individual parts of a system, and of the system as a whole.

In order to gain insight and analyze the complex problem presented by the dynamic variables involved with Seabasing and Joint Expeditionary Logistics (JELo), the Systems Engineering Analysis Baseline Architecture System Evaluator Six (SEABASE-6) model is built using "Image That, Inc.'s" modeling and simulation tool Extend™. The main goal of the model is to facilitate the analysis of multiple Seabasing JELo architectures in order to compare their performance. The model is built to describe the JELo architecture via a parameterized set of input variables that map to different functional areas of the system. For instance, the time that it takes to load a platform at sea as a function of sea state is modeled simply as a time delay. This time delay can then represent any multitude of diverse loading systems (i.e., well deck, integrated launching platform, etc.) by simply modifying the associated time delay variable. Extend™ also allows analytical flexibility by permitting either a deterministic or a stochastic variable input. The model can run deterministically utilizing constant value input variables or stochastically by using distributions. Model inputs are contained within one central database and can be modified directly through the program or through an Excel™ spreadsheet interface. This feature makes changing input variables extremely rapid and efficient. Enclosure 1 lists the model inputs in detail. Model outputs are exported to a workbook in Excel™ format, which allows follow-on analysis of data from each model run in a format that is universal among many other software packages.

8.2 Extend™ Simulation Software

Extend™ is a powerful, leading edge, discrete simulation tool. One of Extend™'s principle benefits is that system architectures may be modeled at a high level of abstraction to gain rough insight into system behavior. Specific system elements can then be targeted for higher resolution modeling as needed, based on system requirements. This stepwise refinement enables very complex problems to be broken down more quickly with varying levels of complexity. Extend™ utilizes a customizable graphical interface, which displays the various relationships within the system. Extend™'s graphical animation allows for a greater understanding of simulation flows during model development and serves as an excellent debugging tool. Unlimited hierarchical decomposition of various model components allows multiple system views with varying degrees of complexity. This hierarchical decomposition property facilitates the use of multiple modules and promotes object reusability throughout the model development life cycle.

8.3 Initial Procedures

The SEABASE-6 model uses proven software development practices and methodologies. Prior to actual code generation, a series of top-level abstract system overviews are developed to establish system boundaries and interfaces. These overviews are developed using the information provided in the JELo Operating Concept [Chapter 2]. Figure 8-1 shows the initial top-level system view produced by the modeling team to understand the major components of the logistics flow throughout the system, without placing any focus on inputs or outputs.

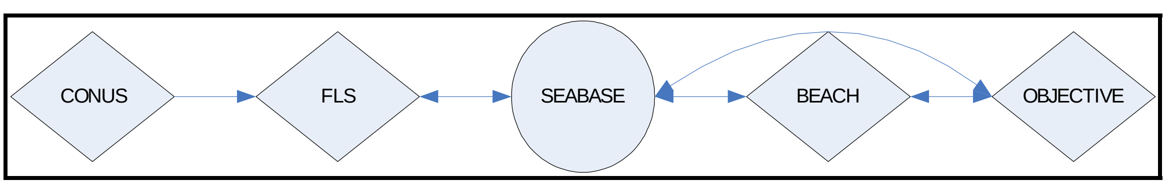

Figure 8-1: Initial Modeling Concept. The Continental United States (CONUS) is the default origin. The Forward Logistics Site (FLS) is the base for prepositioned assets.

8.4 Model Modularity

A great advantage of utilizing Extend™ for this object-oriented discrete simulation is that it facilitates rapid reuse of both predefined objects from the Extend™ library, as well as model-specific, user-designed modules. Hierarchical decomposition also allows the model to be subdivided into logical components or submodules, represented by a single descriptive icon. Double-clicking on the hierarchical block opens a new window displaying the submodel, which greatly simplifies the representation of the model and allows the user to hide and show model details as desired. Figure 8-2 shows the initial JELo architecture screen developed using Extend™. Each block represents a single module and contains numerous, more detailed modules. The top-level modules include: CONUS, Maritime Pre-Positioning Force (Future) (MPF(F)), Expeditionary Strike Group (ESG)-1 and ESG-2, FLS, Combat Logistics Force (CLF), Carrier Strike Group (CSG), Sea Base, Beach, and Objective. The process lines represent the flows between each module. Specific explanation of each module's various inputs and outputs and their interactions are explained in detail later in this chapter.

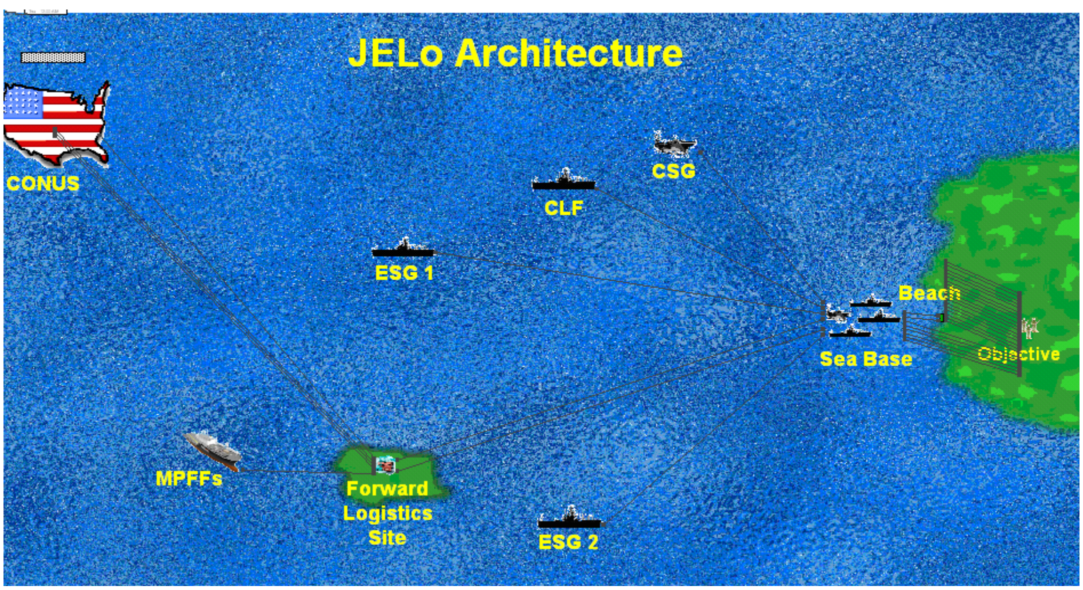

Figure 8-2: JELo Top-Level Overview. This represents the main modules defined by the simulation.

8.5 Model Database

To create uncomplicated user-modified inputs, a relational database is integrated into the model. By separating the data from the model, the database offers fast scenario implementation, flexible analysis, and improved data management. The database serves as a list of input tables that the model draws during simulation. This database has the unique ability to import and export data via an add-in interface with Microsoft Excel™. The add-in enables the creation of database workbooks, which serve as the Excel™ data interface. When a model input is changed in the database table, the input value is modified everywhere in the model that references the database input variable. This feature allows for rapid, convenient, and efficient change management of model variables in a central location without having to change various values that are distributed/hidden throughout the model. In addition, this feature reduces the chance that there is a different parameter value in place when that parameter is used in more than one location throughout the model.

8.6 Sea State Module

Two of the dominate performance drivers of the Seabased JELo system are the at-sea transfer/loading delay and connector speed of advance. Both the loading delays and connector speeds are a function of, and highly dependent on, sea state. To make this analysis possible, a sea state module is created and utilized in multiple modules throughout the model. All input variables whose performance is affected by sea state are entered into the model as a function of sea state condition. SEABASE-6 models three separate and distinct sea state conditions (sea states 2, 3, and 4). These three sea states are chosen as they represent the greatest change in performance across the entire system based on historical research. Component performance values used as input for sea state 2 are also assumed to represent sea states 0 and 1. This assumption is made to simplify the model and to gain insight into the three sea states that are most predominant around the globe on a basis of probability. Sea states greater than 4 are not modeled. The user can modify all system component values that are a function of sea state, so that any geographical area of the world may be modeled if supporting sea state data is available.

Sea state is modeled using Markovian stationary transition probabilities with three possible states (sea state 2, 3, and 4) on a 6-hr cycle. This means that the sea state can at most, change every 6 hrs. All delays or activities in the model that are a function of sea state will utilize the same sea state during that 6-hr period. This method more accurately models the historical weather patterns of the simulated geographical area. It also prevents the sea state from jumping directly from 2 to 4 without first passing through sea state 3.

8.7 Units of Measure

Supply commodity units of measure are standardized with Marine Corps planning factors to reduce the amount of unit conversions within the model. English standard units for area and volume are utilized to match the preponderance of the literature describing Seabasing and JELo systems. Distance is modeled in nautical miles, and times and rates are input in terms of hours. Table 8-1 reflects the standard units of measure for the SEABASE-6 model inputs and outputs.

Measure	Units
Fuel	Gallons
Water	Gallons
Ammunition	Pounds
Distance	Nautical Miles
Time	Hours
Speed	Nautical Miles per hr (kts)
Area	Square Feet
Volume	Cubic Feet

Table 8-1: SEABASE-6 Standard Units of Measure.

8.8 Model Module Description

The logistics processes are grouped into modules. These modules follow three distinct phases: closure, employment, and sustainment. The Assembly Phase takes place during the Closure Phase. Some modules overlap and play a part in more than one phase. The functions of each module are explained in the following sections.

8.9 Closure

The model's Closure Phase tracks the progress of troops, their equipment and Sea Base components from their point of origin up until they converge at the Joint Operations Area (JOA) to form the Sea Base.

8.10 CONUS

The simulation begins in the CONUS module shown in Figure 8-2. Troops and the various air assets are generated here and transit to the FLS. Although the term CONUS is used, it merely reflects a point of origin for the forces and may, in fact, represent a forward base in some architectures and scenarios. Distances from CONUS to the FLS and the Sea Base are user-input and easily changed.

8.10.1 Combat Force Transit

At the start of the simulation, the model generates the combat force troops and they enter a user-specified readiness delay that simulates the alert posture of the forces. After this delay, the troops transit to the airport and are loaded onto each aircraft. The number of aircraft required is dependent on the input value for aircraft capacity. This logic allows for flexibility in capacities among current and future platforms. Each aircraft experiences a user-defined loading delay. Departures are modeled as a single runway, therefore aircraft are sequenced and scheduled to take off at a user-specified time interval. These user-defined delays enable the model to evaluate numerous scenarios dealing with transport aircraft availability and response times. The troop transport aircraft then transit to the FLS. The SEABASE-6 model calculates the transit delay based on a user-specified speed and distance. In-flight winds and delays are not modeled.

8.10.2 Self-Deploying Aircraft Transit

SEABASE-6 also models the transit of self-deployable aircraft. Self-deployable aircraft are those platforms that fly under their own power from their point of origin to the FLS or Sea Base. In the 2015 Baseline Architecture (2015 BLA), the MV-22 aircraft demonstrates this capability. At the start of the simulation, the MV-22s deploy from CONUS and transit to the FLS. In actuality, this flight path is nothing more than a

distance and can resemble a flight between any points on the globe. The user specifies the number of self-deploying aircraft and their corresponding readiness delay. This readiness delay accounts for the time between the actual deployment order and the time that each aircraft gets airborne (i.e., squadron readiness delay, time required to set-up in-flight refueling assets, etc.). Once airborne, the SEABASE-6 model calculates the transit delay for the self-deployed aircraft based on a user-specified speed and distance. In-flight winds and delays are not modeled. Aircraft reliability is modeled by a user-specified value. The product of the reliability and the initial quantity of aircraft represents the total quantity of aircraft that arrive at the FLS or the Sea Base.

8.10.3 Non-Self-Deploying Aircraft Transit

SEABASE-6 also models the non-self-deploying aircraft. Non-self-deploying aircraft are those platforms that must be transported by another connector to arrive at the FLS or the Sea Base. In the 2015 BLA, these aircraft are the CH-53, UH-1, AH-1, and SH-60. At simulation start, a user-specified squadron readiness delay is applied to non-self-deploying aircraft to simulate alert posture. A user-specified maintenance delay is also set for each aircraft to simulate the amount of time that it takes to disassemble and/or prepare the aircraft for transfer. This delay may also be used to model the time required for the Air Mobility Command (AMC) to establish the air bridge. Additionally, a user-specified quantity of transport aircraft, as well as their corresponding sequence delays, may be entered. A user-specified loading delay is applied to the transport aircraft to simulate loading times. Each transport aircraft carries a single non-self-deploying aircraft. To simulate transport aircraft that are capable of carrying multiple non-self-deploying aircraft, the user may adjust the loading delays and the sequencing delays for departing aircraft. The model calculates the actual transit delay based on user-specified speed-of-advance and distance to travel. In-flight winds and en route delays are not modeled.

8.11 Forward Logistics Site

As the troops and aircraft transit to the FLS, the MPF(F)s also transit to the FLS. The distance between the MPF(F)s and the FLS is user-specified. The number of

MPF(F) ships is also a user-specified value. Before an MPF(F) can be loaded, its non-self-deploying aircraft inventory must first be reassembled. This process is modeled by a user-specified aircraft assembly delay at the FLS. It is assumed that the combat gear is already prepositioned on the MPF(F) ships. MPF(F) ship loading is simulated when the user-specified inventory of combat troops and mission ready aircraft are assembled at the FLS. The user can input the number of piers available at the FLS to reflect any port facility. A user-specified MPF(F) transfer delay is modeled to account for the time delay required to load the MPF(F) ship. Loading delays can also be user-input to vary with sea states to allow modeling of at-sea transfers.

8.12 Forward Deployed Units

This module accounts for the forward deployed units. These include the CLF, ESG 1 and 2, MPF(F), and CSG.

8.12.1 Combat Logistics Force

SEABASE-6 can model multiple CLF ships. The actual quantity of CLF ship(s) is a user-input and the CLF originates at a user-specified distance from the Sea Base. This allows various CLF assumptions to be modeled. A CLF ship that originates at sea can be used to model a predeployed or CSG CLF asset, while one that originates at the same distance as the FLS to Sea Base can model an attached CLF that supports only the MPF(F) squadron. A user-input CLF readiness delay acts at the start of the simulation to model any initial delays. The CLF ship then proceeds to the Sea Base with a user-specified quantity of supplies (food, fuel, water, and ammunition). SEABASE-6 calculates the transit delay based on user-inputs for distance and speed-of-advance as a function of sea state.

8.12.2 Expeditionary Strike Group

SEABASE-6 models up to two ESGs. A user-defined range from the Sea Base models their point of origin. The ESGs are used to model the ESGs' synchronization with the Maritime Prepositioning Group (MPG) to form the Sea Base. Their corresponding logistical footprints are not modeled (outside the scope of this project). Their functionality in the model is simply to transit to the Sea Base when the simulation

starts. The Sea Base is not considered to be formed and ready to employ troops until the two ESG units arrive. The start of the simulation encounters a user-specified readiness delay to model ESG force alert posture. If alternative architectures do not require any ESG synchronization, the model user may specify the readiness delay and distance to travel as a 0 value. SEABASE-6 calculates the transit delay based on user-inputs for distance and speed-of-advance as a function of sea state.

8.12.3 Carrier Strike Group

SEABASE-6 models a single CSG. Its purpose is to represent synchronization between Sea Shield and Sea Strike of CSG aircraft and the MPG/Sea Base. The logistical footprint of the CSG is not modeled (outside the scope of this project). The CSG's functionality in the model is to transit to the Sea Base at simulation start. The Sea Base is not considered to be formed and ready to employ troops until the CSG arrives at the Sea Base. A user-specified readiness delay represents CSG force alert posture and acts at simulation start. The distance for the CSG to travel to the Sea Base is user-specified to permit modeling numerous CSG assumptions. If alternative architectures do not require any CSG support, the model user may specify the readiness delay and distance to travel as a zero value. SEABASE-6 calculates the transit delay based on user-inputs for distance and speed-of-advance as a function of sea state.

8.13 Sea Base Formation

Convergence at the Joint Operations Area by the two ESGs, CSG, and MPF(F) constitutes the formation of the Sea Base. At this time, the ESGs and the CSG modules are disabled. The commodities from each individual MPF(F) ship are combined into a common inventory pool that represents the Sea Base inventory.

Once the ESGs, CSG, and MPF(Fs) arrive at the operating area position, SEABASE-6 considers the Sea Base formed. The employment phase starts only after the Sea Base forms. Within this module, an EXTEND™ holding tank accumulates the specified number of ships from each variety to arrive. The ESG ships are batched into a single unit, while the MPF(F) ships are all counted individually. These items are released simultaneously once the last one arrives, marking the Sea Base formation time.

8.13.1 MPF(F) Commodity Visibility

Upon arrival at the Sea Base, the MPF(F) ships enter the commodity visibility module. Here, the commodities (troops, equipment, food, fuel, water, and ammunition) carried by the MPF(F)s are made visible to the modules utilized for the employment and sustainment phases of the model. The model can now use these commodities for inventory and consumption calculations. This portion of the model extracts the individual MPF(F) commodity quantities and sends them to the Sea Base commodity inventory storage module.

8.13.2 MPF(F) Commodity Storage

Once the commodities carried by the MPF(F) ships are made visible in the model, the commodity storage module receives and stores the commodities via a commodity queue. When a connector is loaded with items at the Sea Base, the items decrement from the commodity queue and reduce the Sea Base inventory. As items arrive on resupply or CLF ships, the transferred commodities are added to the Sea Base inventory. The consumption module also decrements the commodity queue as a function of the Sea Base consumption rate for those items used by the Sea Base (food, fuel, and ammunition). The Sea Base utilizes a consumption rate for food based on the number of personnel at the Sea Base. The ammunition consumption rate for the Sea Base is user-specified and includes ordnance delivered by the strike support aircraft embarked on the MPF(F) ships. MPF(F) own-ship fuel is not modeled. However, cargo fuel for use by embarked platforms and ground forces ashore is modeled. The consumption of fuel at the Sea Base is a user-specified rate. For the 2015 BLA, this rate includes daily fuel consumption by generic aircraft not individually modeled such as the JSF, AH-1, and SH-60 aircraft.

8.14 Employment

The employment phase of the model starts once the Sea Base is formed. Recall that it is assumed that Assembly took place as the MPF(F) that loaded troops and non-self-deployed aircraft at the FLS transited to the Sea Base. Employment is the insertion of three battalion landing teams (BLTs) from the Sea Base to their objectives ashore. During employment, two surface BLTs are sent to the shore objective via surface

assault connectors, while a single vertical BLT is sent to the inland objective via air connectors. Arrival at the objective (inland or beach) of the last connector transporting any part of the BLTs marks the end of the employment phase.

8.14.1 MPF(F) to Connectors

As each MPF(F) ship arrives at the Sea Base, the embarked surface assault connectors are offloaded and ready to transfer troops and equipment to the objective. For the 2015 BLA, these connectors are LCACs, LCU(R)s, CH-53s, MV-22s, and UH-1s. Each MPF(F) transports a user-specified quantity of each connector. The model allows the user to utilize two surface assault connector types and up to three types of air connector types. Once the embarked connectors offload at the Sea Base, they are considered operational.

8.14.2 Connector Transit

All connectors may be used for both logistical resupply between the Sea Base and the objective, as well as for medical evacuation of wounded personnel. The only exception to this policy is the connector identified in the 2015 BLA as the UH-1. The UH-1 connector is modeled to serve only in a medical evacuation transport role and cannot carry other types of supplies.

8.14.3 Parallel Loading Logic

The SEABASE-6 model allows the user to input the quantity of surface craft loading points (i.e., Integrated Landing Platforms) and operational air deck spots dedicated to logistics per MPF(F). The user specifies the number of operational loading platforms available to each connector on a per MPF(F) ship basis. Once an operational deck spot is available to a connector for loading, delays for strike up, assembly, and transfer are encountered prior to actual connector departure. All three of these delays are user-input as a function of sea state. These delays provide the flexibility to model diverse transfer mechanisms, means of assembly, and inventory and storage systems. SEABASE-6 also allows the user to specify if the first wave of connectors can bypass the strike up delay to simulate that the connector is pre-loaded prior to initial operations.

8.14.4 Number of Trips Required

The number of trips required for each connector during the employment phase is user-specified, based on connector payload capacity and payload requirements. The user must specify exact payloads for each connector trip in the load plan database. The connectors must complete the specified number of trips prior to entering the sustainment phase. When a connector returns to the Sea Base during the employment phase (scripted trip), a logic block determines whether the specified number of trips have been completed. If the specified number is not complete, the connector continues in the employment phase and loads the next user-specified scripted payload. When the specified number of trips is complete, the employment phase is complete and the sustainment phase commences.

8.14.5 Load Out

Each connector is loaded with a user-defined amount of food, fuel, water, ammunition, troops, and vehicles to reflect its actual payload. During the employment phase, the load-out for each connector is predetermined from a user-defined script in the database. In this phase, each connector is capable of carrying more than one type of supply. When loaded connectors depart the Sea Base, logic signals decrement the inventory of commodities at the Sea Base. Air connectors proceed to the in-land objective and surface connectors to the beach. A transit delay is calculated based on user-input distance and speed-of-advance. Specific wind and current effects are not modeled.

8.14.6 Connector Attrition

SEABASE-6 models connector attrition. The user-specified probability of kill for each connector is per half trip. The connector is subjected to this probability of kill during both the ingress and the egress portions of the trip. This half-trip attrition logic provides the opportunity for supplies to arrive at the objective prior to connector attrition approximately 50% of the time. If attrition occurs during ingress, the equipment is lost. Once a connector attrites, it exits the simulation and is not regenerated.

8.14.7 Connector Fuel Consumption

While connectors transit to the objective or the beach, their fuel consumption is calculated based on user-specified consumption rates and decremented from the Sea Base fuel inventory. Air connector fuel consumption rates are based on the average weight and drag for a full external payload on the ingress leg and half-mission fuel weight with base external drag on egress. Surface connector fuel consumption rates are based on full payload weight during the ingress and empty weight on the egress leg.

8.14.8 Connector Off-Load

A user-specified transfer delay is applied to connectors unloading assets at the beach and the objective. This delay can be a function of combat level if desired.

8.14.9 Air Connector Commodity Visibility

When an air connector arrives at the objective to deliver its payload, it experiences a user-defined transfer delay based on the current level of combat. The connector's commodities are made visible to the objective module, which deposits them into the objective's commodity storage. After delivery, air connectors transit back to the Sea Base, with a calculated transit delay based on user-input for speed-of-advance and distance.

8.14.10 Connector Return to Sea Base

Once a connector unloads its payload at the beach or the objective it returns to the Sea Base to pick up its next pre-determined load. The return transit delay is calculated based on user-input distance and speed-of-advance.

Before the empty air connector returns to the Sea Base, the model first checks to see if there is a wounded soldier waiting at the objective. If there is, the air connector is diverted to pick-up the wounded (medical evacuation module). The assumption is that all air connectors are configurable to carry wounded troops. If there are no wounded soldiers, the air connector transits back to the Sea Base. This calculated transit delay is a function of user-input for speed-of-advance and return distance.

8.14.11 Nondedicated Medical Evacuation Air Connectors

As an air connector enters the medical evacuation module, it loads the lesser of either the user-specified maximum litter capacity or the current number of wounded troops. The air connector does not wait for the maximum value of troops it can carry if the number of wounded troops is less than its carriage capacity. The delay associated with loading wounded soldiers is a user-input.

8.14.12 Dedicated Medical Evacuation Air Connector

SEABASE-6 models one air connector that is dedicated to the medical evacuation mission. In the 2015 BLA, this air connector is the UH-1Y. The loading logic and delays are identical to those for the nondedicated medical evacuation air connectors.

8.14.13 Ground Vehicle Transit

Once a surface connector delivers a vehicle ashore, the vehicle begins its transit to the inland objective. Vehicle transit delay is calculated based on a user-defined vehicle speed and distance. SEABASE-6 calculates vehicle transit fuel consumption based on a user-defined rate and decrements the on-hand fuel inventory at the objective.

8.14.14 Objective Commodity Storage

The commodity storage module at the objective stores the delivered commodities. This module represents on-hand inventory of supplies at the objective. When a connector deposits commodities at the objective, they are added to the on-hand inventory. The consumption module decrements the commodity storage at a user-specified consumption rate per unit time.

8.14.15 Ground Vehicle Commodity Visibility

As each ground vehicle arrives at the objective, its commodity payload (troops, food, fuel, water, and ammunition) becomes visible to the objective module. This module extracts the commodities and deposits them into the commodity storage at the objective.

8.14.16 Ground Vehicle Attrition

SEABASE-6 models vehicle attrition based on user-input rates. This module simulates a reduction in fuel consumption due to vehicle losses over time (both combat and/or maintenance losses). The vehicle attrition module is deterministic and relies on a user specified vehicle loss quantity per unit time. For example, if the user chooses to attrite 1 M1A1 tank every 36 hrs, the model will decrement the objective's on-hand inventory of M1A1 tanks by a quantity of 1 every 36 hrs.

8.14.17 Troop Attrition Module

Wounded troops in need of a medical evacuation are generated from a user-specified distribution that is a function of the current level of combat (assault/sustain). Wounded troop quantity is drawn from their distribution each hour. Wounded troops are placed into a holding queue at the objective and are picked-up by medical evacuation connectors to transport them to the Sea Base. When wounded troops depart the objective, on-hand inventory decrements.

8.15 Consumption Module

Every hour inside the simulation, a combat level is selected based on a user-specified probability distribution. From this combat level, the model applies a user-input consumption rate to the supply commodities of food, water, and ammunition by multiplying the specific commodity consumption rate by the number of troops at the objective. The troops in the wounded commodity queue are not taken into account for this calculation. An increase in combat level results in an increase in the quantity of troops in the wounded queue. The resultant quantities are decremented from the objective's on-hand inventory.

Combat level also drives the fuel consumption rate; however, fuel demand is a function of vehicle type and quantity vice troop levels. For vehicles at the objective, the model calculates fuel consumption hourly. To account for the fact that vehicles are not in use 24 hrs a day, a user-defined "usage" percentage is modeled, which reflects the percentage per 24-hr period that vehicles are in use. This "usage" percentage facilitates modification of fuel consumption rates for fuel efficiency analysis and their impact on

logistics. Vehicle fuel consumption is calculated hourly by multiplying together the user-inputs for "usage" percentage and consumption rate. The consumption module decrements the objective's on-hand fuel inventory by the amount of fuel consumed.

8.16 Sustainment

The sustainment phase begins once the employment phase ends. The sustainment phase consists of keeping both the Sea Base and the forces ashore supplied with an adequate amount of commodities (food, fuel, water, and ammunition).

8.16.1 Asset Visibility

SEABASE-6 models actual commodity inventories at both the objective and the Sea Base to simulate real time, 100% asset visibility. This simulates that the Sea Base logisticians have real-time, accurate information of on-hand inventory at both the Sea Base and the objective. The model uses 100% asset visibility to simulate an adaptive Sense and Respond logistics system.

8.16.2 Sense and Respond

SEABASE-6 models a Sense and Respond logistics system with 100% asset visibility of inventory levels at the objective and Sea Base, supplies in transit, and supplies ordered, but not filled. The model calculates priorities based on actual real-time inventory levels at the objective. The reorder point for each commodity at the objective is a user-input value representing an inventory level measured in days-of-supply. This modifiable reorder point facilitates the evaluation of different safety-stock levels at the objective. The commodity that is below its user-defined reorder point, and has the lowest on-hand days-of-supply inventory, becomes the highest priority. The highest priority commodity then departs the Sea Base as the payload on the next available connector. Each connector can only carry one type of supply per trip. Connector payload capacities are user-input as a function of range to allow for decreasing payload capacities at longer ranges.

The model verifies that the requested commodity is in the Sea Base inventory. If the Sea Base can fill the order, the connector loads the commodity quantity determined by the range from the Sea Base to the objective based on user-defined connector range-payload characteristics. If the Sea Base cannot fill the highest priority commodity order due to low inventory, the second highest priority commodity is loaded.

8.16.3 Scheduled Replenishment

SEABASE-6 models FLS resupply from either CONUS or an advanced base. Although not used in our project due to scope limitations, it is included for model future use. Once the Sea Base has been formed, a user-specified timing trigger is passed to the scheduled replenishment module to initiate the generation of resupply ships. The resupply ship receives a user-specified payload of food, fuel, water, and ammunition. Each resupply ship goes through a user-specified loading delay. Once the first resupply ship is generated, a new one is generated at a user-specified time interval.

8.16.4 Resupply Platform to Forward Logistic Site Storage Location

The resupply ship transits from CONUS/Advanced Base to the FLS over a user-specified distance and speed-of-advance. Upon entering the FLS, its payload of food, fuel, water, and ammunition is unloaded to a storage location. When a CLF arrives at the FLS, it receives a load-out from the FLS storage location. This module is not active in this study, based on the assumption that the logistics flow from CONUS to FLS is adequate to meet the Sea Base demand.

8.16.5 Combat Logistics Force Return

In this module, the Combat Logistics Force (CLF) has restocked at the FLS and returns to the Sea Base. SEABASE-6 calculates the en route transit delay dependent on the user-specified distance and CLF speed-of-advance. Once the CLF arrives at the Sea Base, it enters a holding status until the Sea Base is able to accept its commodities. Once the Sea Base sends a demand signal to the CLF for underway replenishment, the CLF transfers its commodities to the Sea Base and returns to the FLS.

8.16.6 Combat Logistics Force Unload/Delays

The CLF remains on-station until the Sea Base inventory can accept the entire CLF off-load for the commodity in highest demand. At this time, the CLF ship transfers its entire off-load of the highest demand commodity to the Sea Base. The CLF also transfers the remaining classes of supplies in sufficient quantities to top-off the Sea Base without exceeding the user-specified Sea Base maximum per commodity. The CLF ship then returns to the FLS to reload. The CLF returns to the FLS empty of the most demanded supply and partially loaded with the supplies that were not fully utilized. This logic allows the CLF ship to minimize its return time to the Sea Base for the most heavily demanded class of supply.

The transfer of commodities between the CLF and the Sea Base is modeled as a user-input time delay. This transfer delay can be a function of sea state. In addition to the transfer delay, the MPF(F) experiences a user-specified delay as a function of sea state for commodities strike down (storage). Different inventory and storage systems can be modeled via this user-input delay. Commodities are not visible for use in the simulation until the commodities have gone through the strike down delay.

8.16.7 Connector Availability

SEABASE-6 models connector availability. Availability is modeled by "failing" a connector after reaching a user-specified Time-Between-Failure (TBF). The user can input either a constant TBF or a distribution for failure times.

Each connector arrives at the Sea Base in an "up" operational status and is assigned a TBF time drawn from the user-input. Prior to each trip, the model queries the failure time of the connector. If the failure time is exceeded, the connector is considered "down" for maintenance and enters the "awaiting maintenance" queue. If the assigned "failure" time is not exceeded, it is assigned a trip. If the time of failure for a connector is reached while on a trip, the connector is allowed to complete the trip without any penalty, but is "down" once it arrives back at the Sea Base.

Failed aircraft are sent to the "awaiting maintenance" queue. Here they wait until a maintenance spot is open so that they may be repaired. Time-to-Repair (TTR) times are user-specified and may either be a constant or drawn from a distribution. Once the repairs are made to the connector, it is assigned a new future failure time and returned to service.

8.16.8 Connector Cycling

SEABASE-6 permits the user to define an operational tempo for the Sea Base during the sustainment phase by cycling connectors on and off. During the employment phase, all assets of the Sea Base are operating to employ forces in the shortest amount of time. However, the sustainment phase lasts much longer and operational tempo must be considered. SEABASE-6 allows user-input to turn on/off MPF(F) ships and their respective connectors to simulate crew rest cycles and underway replenishment windows. The user specifies a percentage of Sea Base assets that are "first up" during the sustainment phase and their time duration to remain operational (cycle time). At the end of that cycle time, the remaining Sea Base assets become operational for the next cycle (same duration) while the "first-up" Sea Base assets are turned-off. This cycle then repeats itself for the duration of the sustainment period. For example, if the user inputs a Sea Base percentage of 50% and a cycle time of 12 hrs, half of the MPF(F) ships and connectors will be operational at any one time. The first 50% of the Sea Base assets are operational during the first 12 hrs and the remaining 50% of the assets are operational during the second 12 hrs, in a repeating fashion. Various operational tempo assumptions can be evaluated using this input parameter.

8.17 MPF(F) Attrition

SEABASE-6 models MPF(F) attrition. MPF(F) attrition is based on a one-time user-specified probability of kill as a MPF(F) enters the Joint Operating Area (JOA) to form the Sea Base. If the MPF(F) is killed, it exits the simulation and none of the commodities or connectors embarked on the platform are available for future operations or regenerated.

8.18 Model Validation and Verification

Model validation is the process of ensuring that the model represents the actual system. Since the SEABASE-6 model is a tool to simulate future Seabasing and JELo architectures, the model cannot truly be validated, as there is no real system for comparison. Although the model can predict future performance of the system, these predictions cannot be validated with any certainty. Even though the model cannot be validated, it can accrue validity over time. Comparing SEABASE-6 simulation results to those of other similar models developed by partnership teams/agencies is an on-going effort and one method in which validity may be accrued. Comparison of the SEABASE-6 model with the Center for Naval Analysis (CNA) model used in their MPF(F) Analysis of Alternatives study yields very positive results. The CNA study simulated landing a single BLT from four unconstrained, distributed ships, from 25 NM at sea in approximately 14.8 hrs.[236] Utilizing the same deterministic assumptions, LCAC speeds of advance and transfer delays as the CNA study, the SEABASE-6 model returned an output of 14.3 hrs (a difference of less than 5%).

Model verification is the process of ensuring that a model works as expected. Verification of the SEABASE-6 model is an on-going and iterative effort utilizing multiple means to meet the objective. The SEABASE-6 model is built in stages (modules). Each stage is coded, debugged, and run to ensure that the results seem reasonable and that they match expected results obtained from side-study analysis or simple back-of-the-envelope calculations. This type of testing is very similar to the software test methodology known as CABTAB (Code-a-Bit and Test-a-Bit).

SEABASE-6 model stress testing is also a part of the verification process. A full factorial controlled test permits evaluation of overall system behavior and exposes any unpredicted factor interactions. Sea state, rate of consumption, ranges from Sea Base to shore and range from shore to objective stress the SEABASE-6 model. The full 54-trial factorial test looks at three sea states (2, 3, and 4), two levels of consumption

[236] Robert M. Souders, Suzanne Schulze, Yana Ginburg, and John Goetke, "MPF(F) Analysis of Alternatives: Final Summary Report," (Alexandria, VA: The CNA Corporation, CNR D0009814.A2/Final, April 2004), p. 74.

(assault and sustain), three ranges between the Sea Base and shore (25, 40, and 100 NM), and three ranges between the shore and the objective (10, 50, and 100 NM). The full factorial test also serves as a litmus test for model stability, with the model accruing over 6,500 minutes of run time, while exploring the boundaries of the system and covering the entire planned factor space.

Sensitivity analysis provides yet another form of verification for the SEABASE-6 model. A series of controlled experiments determines the system response due to a change of just one input parameter value. Sensitivity studies look at all phases of the model to include closure, employment, and sustainment. Sensitivity analysis not only provides valuable insight into the impact of each variable on overall system response, but also verifies that system response is logical and of the proper magnitude with respect to the modified variable and value.

8.19 Model Limitations

As with any model, SEABASE-6 has numerous constraints and limitations imposed on it in order to simplify the complex Seabasing and JELo problem. These constraints and limitations permit the system to be modeled at the correct level of abstraction to ensure that key insights are drawn from the resulting data the model generates.

8.19.1 CONUS Logistics

SEABASE-6 does not model the logistics infrastructure within CONUS or an Advanced Base. Logistic flows within CONUS or the Advanced Base are modeled as a simple user-input delay.

8.19.2 Sea State

Sea state is modeled identically throughout the model. The sea state at the beach objective is the same sea state that is seen at the FLS, as well as the open ocean. See Section 8.6 for more detailed discussion on the sea state module.

8.19.3 Combat Logistics Force Return Logic

The CLF ship does not replenish the MPF(F) ships one at time, but treats them as one entity (Sea Base). The actual flow of supplies between platforms during underway replenishment is not modeled. A user-input CLF transfer delay models the underway replenishment process. This delay is also a function of sea state.

8.19.4 Assembly at Sea

Assembly at sea is modeled only as a user-specified delay as a function of sea state. To simulate that assembly takes place on board the MPF(F) ships en route to the JOA, the delay can be set to 0.

8.19.5 Multiple Objectives

SEABASE-6 models only a single land objective. The complexities and network interactions of employing and sustaining forces at multiple objectives simultaneously are not modeled.

8.19.6 Carrier Strike Group and Expeditionary Strike Group Logistics

The logistical footprints of both the CSG and ESG are not modeled. However, the CSG and ESG are required members of the Sea Base. In order for the Sea Base to be considered formed and operational, the CSG and ESG must be present.

Enclosure 1: Model Inputs Glossary

Aircraft from CONUS: Inputs include the amount and type of aircraft available for transporting troops from CONUS.

Asset Visibility: Includes sense and respond asset visibility delay times, in hours, for both the employment and sustainment phases. This visibility delay is the time required for the associated command and control system to provide information concerning logistics assets.

Availabilities: Each connector has an associated mean time between failure (MTBF) and mean time to repair (MTTR), which is in units of hours. MTBF is the average time between platform breakdowns. MTTR is the average time required to perform corrective maintenance on a particular piece of equipment or platform. The number of maintenance spots refers to the number of locations available to perform corrective maintenance and repair.

Combat Level Priority: Assault 1 refers to the first 10 days of the model-simulated time. Assault 2 refers to the days 11-20 of simulated time in the model. Assault 3 refers to the last 30 days of simulated time in the model. Each input is associated with a table to determine the probability of being in an assault condition or a sustained condition.

Connector Cycling: "First up ratio" refers to the ratio of the first number of MPF(F)s available for sustainment. Cycle time is the amount of time between one group of MPF(F)s switching to begin sustainment operations, while the other MPF(F)s enters crew rest.

Consumption Rates: Allows the input of consumption rates for both the employment and sustainment phases of operations. The connectors have inputs for fuel consumption rates, in gallons per mile, for both a fully loaded vehicle and empty vehicle. Fuel (gallons per mile) full refers to the amount of fuel consumed by a particular vehicle when a full load of cargo is present. Fuel (gallon per mile) empty refers to the amount of fuel consumed by a particular vehicle when empty of cargo.

Current Sea State: This is a constant that reflects the current sea state used for calculations throughout the model. This number is not a user-defined input.

Delays-Combat Level: These delays include transfer delays for the various connectors, on land, for both the employment and sustainment phases. Input time is in hours. For the connectors, the measurement used is a full load. A medical evacuation considers transfer time for only one soldier. This is the loading of the wounded soldier at the objective. The model uses this value and multiplies by the number of soldiers being evacuated.

Delays-CONUS:

- Troop Readiness: Amount of time it takes the troops to assemble and prepare for transit.

- Airport Transit: Amount of time is takes for troops to get to the aircraft.

- Troop Aircraft (A/C) Sequencing: Refers to how often aircraft can take-off from a runway.

- Troop A/C Loading: Amount of time required to load the specified number of troops into the aircraft.

- Resupply Platform Sequencing: Refers to how often the resupply platform leaves CONUS to fly to the FLS.

- MV-22 Squadron Readiness: The level to which the squadron is prepared to perform operations prior to transit from CONUS.

- MV-22 Transit (NM/hr): The normal air speed for the MV-22 is 180 kts. It is assumed that the MV-22 will do 180 kts for 12 hrs and then rest for 12 hrs. Therefore, to simplify modeling calculations, the speed is given as 90 kts for 24 hrs.

- Helicopter A/C Readiness/Disassembly: The amount of time required to disassemble the helicopters (CH-53s and UH-1s).

- Helicopter A/C Loading: The amount of time required to load associated helicopters aboard their respective transport aircraft.

Delays-FLS:

- Helicopter Reassembly and functional check flight (FCF): The amount of time required to reassemble the helicopters and perform the FCF.

Delays-Forward Deployed:

- CSG Readiness: The amount of time required for the CSG to reach a state of readiness prior to transit.

- ESG Readiness: The amount of time required for the ESG to reach a state of readiness prior to transit.

- CLF Readiness: The amount of time required for the CLF to reach a state of readiness prior to transit.

- MPF(F) Readiness: The amount of time required for the MPF(F) to reach a state of readiness prior to transit.

Delays-Sea Base:

- CH-53 Sequencing: Refers to how often the associated aircraft is sent from the sea base to the objective. This delay is used for planning factors only and is not taken into account when using sense and respond logic.

- MV-22 Sequencing: Refers to how often the associated aircraft is sent from the sea base to the objective. This delay is used for planning factors only and is not taken into account when using sense and respond logic.

- Medical Evacuation Readiness: Amount of time required to reconfigure the primary medical evacuation aircraft, following the transportation of supplies, for troop evacuation.

- A/C Redistribution: The various aircraft types are not distributed among the MPF(F)s during the initial transit from the FLS. This input refers to the amount of time required to redistribute aircraft amongst the MPF(F)s prior to the employment phase.

Delays-Sea State:

- CLF Initial Transit (kts): The speed of the CLF ship, originating in the ocean, transiting to the Sea Base expressed as a function of sea state.

- CLF to Sea Base (kts): The speed of the CLF ship, originating at the FLS, transiting to the Sea Base expressed as a function of sea state.

- CLF to FLS (kts): The speed of the CLF ship, originating at the Sea Base, transiting to the FLS expressed as a function of sea state.

- CLF Transfer (hrs): The amount of time required to transfer items both at the Sea Base and FLS expressed as a function of sea state.

- MPF(F) Transit (kts): The speed of the MPF(F) ship expressed as a function of sea state.

- MPF(F) Transfer (hrs): The amount of time required to transfer items at the FLS expressed as a function of sea state.

- ESG Transit (kts): The speed of the ESG expressed as a function of sea state.

- CSG Transit (kts): The speed of the CSG expressed as a function of sea state.

- LCAC Initial Transit (kts): The speed of the LCAC from the Sea Base to the beach expressed as a function of sea state.

- LCAC Return Transit (kts): The speed of the LCAC from the beach to the Sea Base expressed as a function of sea state.

- LCAC Transfer (hrs): The amount of time required to transfer items at the Sea Base expressed as a function of sea state.

- CH-53 Transfer (hrs): The amount of time required to transfer items at the Sea Base expressed as a function of sea state.

- Medical Evacuation Transfer (per soldier in hrs): The transfer delay associated with loading and unloading wounded troops at the Sea Base.

- Resupply Ship Transit (kts): The speed of the resupply ship from CONUS to the FLS expressed as a function of sea state.

- Resupply Ship Transfer (hrs): The amount of time required to transfer items at CONUS and the Sea Base expressed as a function of sea state.

- Strike Up (hrs): The amount of time required to transport equipment from below deck of the MPF(F) ship to the main deck of the ship, expressed as a function of sea state. This is the equipment that the MPF(F) will transfer to the connectors.

- Strike Down (hrs): The amount of time required to transport equipment from the main deck of the MPF(F) ship to below deck, expressed as a function of sea state. This is the equipment received from the CLF.

- Assembly (per vehicles in hrs): The amount of time required to assemble the associated vehicle.

Distances: (all in Nautical Miles (NM))

- Sea Base to Beach Head: Not considered an input. It is a block used in the model to write the current distances. This value is used in calculations throughout the model.

- CSG to Sea Base: Distance from the CSG to the Sea Base in NM.

- ESG 1 to Sea Base: Distance from ESG 1 to the Sea Base in NM.

- ESG 2 to Sea Base: Distance from ESG 2 to the Sea Base in NM.

- CONUS to FLS: Distance from CONUS to the FLS in NM.

- FLS to Sea Base: Distance from the CSG to the Sea Base in NM.

- Sea Base to Objective: Not considered an input. It is rather a block used for the model to write the current distance. This value is used in calculations throughout the model.

- Beach Head to Objective: Not considered an input. It is rather a block used for the model to write the current distance. This value is used in calculations throughout the model.

- MPF(F) to FLS: Distance from the MPF(F) to the FLS in NM.

- CLF to Sea Base: Distance from the CLF to the Sea Base in NM.

- Initial Sea Base to Beach Head: Distance used for LCAC and LCU(R) runs. Once these runs are complete, the distance moves back to the final distances.

- Initial Beach Head to Objective: Distance used for LCAC and LCU(R) runs. Once these runs are complete, the distance moves back to the final distances.

- Initial Sea Base to Objective: Distance used for LCAC and LCU(R) runs. Once these runs are complete, the distance moves back to the final distances.

- Final Sea Base to Beach Head: Final distance used for calculation once LCAC and LCU(R) runs are complete.

- Final Beach Head to Objective: Final distance used for calculation once LCAC and LCU(R) runs are complete.

- Final Sea Base to Objective: Final distance used for calculation once LCAC and LCU(R) runs are complete.

First Connector Wave Strike up in Transit: The input is either 1 or 0, which corresponds to yes and no, respectively. If yes, the strike up on the MPF(F) for the first wave of connectors is performed while in transit to the Sea Base. If no, the strike up on the MPF(F) is not performed until reaching the Sea Base.

Ground Vehicle Attrition Rates:

- Vehicle: The ground vehicle associated with the attrition.

- Assault Time (hours): The mean time between the next vehicle failure for the Employment phase.

- Sustain Time (hours): The mean time between the next vehicle failure for the sustainment phase.

Ground Vehicle Operation: Percentage of ON Time: Amount of time, expressed as a percent, that a vehicle is considered to be running and/or operating. This is used as an input for fuel consumption calculations.

Initial Load-out Configuration CH-53: Initial items with their associated amounts considered in the load-out configuration of one CH-53.

Initial Load-out Configuration LCAC: Initial items with their associated amounts considered in the load-out configuration of one LCAC.

Initial Load-out Configuration LCU(R): Initial items with their associated amounts considered in the load-out configuration of one LCU(R).

Initial Load-out Configuration MV-22: Initial items with their associated amounts considered in the load-out configuration of one MV-22.

Load-out Configuration CLF: Initial items with their associated amounts considered in the load-out configuration of one CLF.

Load-out Configuration Helicopter A/C: Initial items with their associated amounts considered in the load-out configuration of one Helicopter.

Load-out Configuration MPF(F): Initial items with their associated amounts considered in the load-out configuration of one MPF(F).

Load-out Configuration Resupply Ship: Initial items with their associated amounts considered in the load-out configuration of one Resupply ship.

Maximum Resupply Range: The maximum range, in nautical miles, at which the connector can perform a resupply mission.

MPF(F)/Connector Attrition Probabilities:

- Type: Type of connector used in the calculation.

- Assault: Attrition probability during employment phase of operations.

- Sustain: Attrition probability during the sustainment phase of operations.

Number of connectors loaded in parallel (per MPF(F)): The number of Integrated Loading Platforms (ILPs) available.

Number of Helicopter A/C loaded in parallel: The number of aircraft, at CONUS, that can be loaded at the same time.

Number of MPF(F)s loaded in parallel: The number of MPF(F)s, at the FLS, that can be loaded at the same time.

Number of Trips Required for Insertion:

- Initial: Amount of trips required to deliver troops and equipment to their final destination during the initial 10 hrs of employment phase.

- Follow on: Amount of trips required to deliver troops and equipment following the employment phase. These items are not required for the 10-hr employment phase.

Planning Factor Probabilities: Planning factors will be used only if the asset visibility system fails. If using planning factors, the probabilities will be based on an empirical table.

Reliability Rates from CONUS: Refers to the number of MV-22s available to perform operations from CONUS, expressed as a fraction of one.

Reorder Levels: Level at which a particular item will be reordered to maintain two days of supply.

Resupply Holding Capacities CH-53: Amount of cargo the CH-53 can hold, as a function of associated range.

Resupply Holding Capacities MV-22: Amount of cargo the MV-22 can hold, as a function of associated range.

Resupply Waiting:

- Surface Connector: Type of connector used for resupply.

- Number of Load-outs before resupply: The number of LCAC and LCU(R) runs completed prior to the beginning of air resupply runs.

S&R Logistics Critical Levels: This number corresponds to the amount of items considered to be one day of supply.

Sea Base Maximum Capacities: Maximum capacities, in associated units, that can be held within the Sea Base.

Sea State Distribution: Distribution of sea state based on an empirical table of probability.

Ships: The amount and type of ships used throughout the model.

SOA: The speed of a platform in kts.

Troop Attrition Rates:

- Wounded: Rate at which troops attrite.

- Killed: Refers to the fatality rate of troops.

Troop Carrying Capacities:

- Aircraft: Maximum number of troops that can be carried by the associated platform.

- UH-1: Maximum number of troops that can be carried by the associated platform. For medical evacuation only.

- CH-53: Maximum number of troops that can be carried by the associated platform. For medical evacuation only.

- MV-22: Maximum number of troops that can be carried by the associated platform. For medical evacuation only.

Troops:

- To Sea Base: Number of troops delivered to the Sea Base.

- To Objective: Number of troops delivered to the objective.

9. THE BURMA SCENARIO

9.1 Overview

Currently, the Pentagon uses numbered Major Combat Operation (MCO) scenarios and a Global War on Terrorism (GWOT) scenario for budgetary analysis and force planning. The MCO scenarios are large force employments supported by years of deliberate, joint planning. Additionally, much of today's forward presence policy/posture addresses these scenarios. However, the true test of the Sea Base capability, indeed of expeditionary forces in general, comes in the form of a smaller-scale crisis response where the U.S. has little warning and has done little deliberate planning prior to the deployment of forces. Areas of the world that are not near major U.S. logistics centers and/or have constrained or restricted lines of communication also challenge the Sea Base concept. For these reasons, Systems Engineering and Analysis (SEA) Cohort 6 (SEA-6) choose a crisis response in Burma as an analytical scenario over the MCOs.

NPS Joint Campaign Analysis courses have analyzed two "crisis" scenarios that challenge the Sea Base concept. In one scenario, the U.S. responds to a near-peer competitor's aggressive invasion of the island of Palawan in the South China Sea. In the other, the U.S. and its allies support a democratic revolution in Burma (Myanmar). Systems Engineering and Integration Cohort 3 (SEI-3) used a Burma scenario in their study of Expeditionary Warfare.[237] Systems Engineering and Analysis Cohorts 4 and 5 (SEA-4 and SEA-5) used a near-peer scenario in their studies of protecting the Sea Base with Sea Shield and of Maritime Dominance in the Littorals. SEA-6 chooses the Burma Scenario because this study also focuses on expeditionary warfare, and because SEA-6 has previously performed extensive analysis of it.

Burma is a good test of the Sea Base concept for many reasons: the geography presents physical and political challenges, the air and sea lines of communication are long and constrained, the enemy force is credible, and the shortage of well-developed ports and airfields make access a problem. Figure 9-1 shows the constrained geography.

[237] SEI-3 2002 Integrated Project, "Expeditionary Warfare," Naval Postgraduate School, 2002.

9.2 2015 Scenario Background

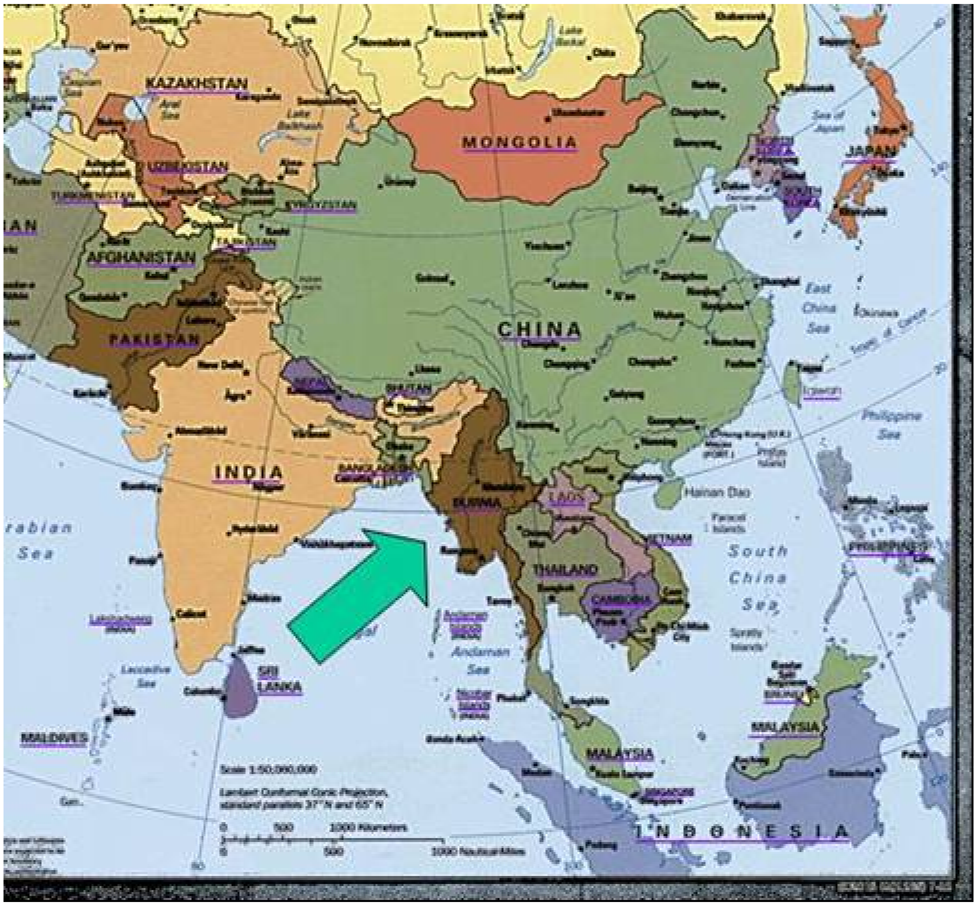

Figure 9-1: Burma and Surrounding Area.[238]

With the Taliban's demise in 2002, Burma (Myanmar) is the world's leading illicit opium producer. In the subsequent years, Burma's military government has expanded its power using increased revenue from drug activity.[239] Southeast Asian factions of the Al Qaeda terror network use the shared isthmus region for training, opium distribution, and as a launching point for piracy missions. The Burmese military regime continues to turn a blind eye toward the terrorists in return for their distribution services. Neighboring countries, Europe, and North America fear that the military regime poses a threat to the Straits of Malacca.

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[238] Note the shared borders with both India and China; also note the long coastline and proximity to the Straits of Malacca.

[239] A majority of the background for this scenario was taken from the Burma Scenario write up (Chapter VI) in the SEI-3 2002 Integrated Project Report "Expeditionary Warfare," Naval Postgraduate School, Monterey, CA, 2002.

China is concerned with the Burmese drug trade on its own borders. However, China takes a proactive approach, supporting the Burmese military in an attempt to gain the regime's help in controlling the drug flow and to check what it perceives as India's expansion. Since 1990, China has sold military equipment to Burma and provided military and technical advisors. In addition to arms sales, the Chinese assisted Burma in building and improving naval facilities at the port city of Myeik, the port city of Akyab along the Burmese coast of the northern Bay of Bengal, and the port city of Moulmein due east of Rangoon. To further strengthen its power, the military regime used their improved military capability against members of the old People's Assembly and the Shan rebels, both pro-democracy movements.

In 2015, a popular pro-democracy uprising occurs in Bhamo (north-central part of the country). The freedom fighters establish a stronghold and ask the remaining members of the old People's Assembly to establish a new, democratic Burmese government in Bhamo. In response, the Burmese people south of Rangoon along the Malay Peninsula take up an armed resistance against the military regime's forces. With covert Thai support (arms shipments, training, etc.) the southern freedom fighters take control of the country south of Ye and establish headquarters in Tavoy. With tenuous strongholds in the north and south, the fledgling democratic movement calls for assistance from the international community.

The military regime responds by threatening to close all Southeast Asian waterways if any country intervenes on behalf of the "insurgents." In addition to mobilizing forces, the military regime activates the air defenses around Rangoon; deploys mobile anti-ship missile systems; deploys their Naval Special Forces; and establishes regular maritime patrols with their ships.

The Association of Southeast Asian Nations (ASEAN) member-states, the United States and the European Union (E.U.) recognize the pro-democracy forces as the legitimate government of Burma. ASEAN and the United States calls for an immediate cease-fire and demand that the military government relinquish power to a transitional government, headed by the Shan rebel faction, with popular elections soon to follow.

China and India support the cease-fire, but China independently warns the United States that they will not tolerate any U.S. military "adventurism." China promises a United Nations (U.N.) Security Council veto if the U.S. tries to organize a military coalition against Burma under U.N. auspices.

In response to the situation, the U.S. National Command Authority, after conferring with its ASEAN allies, tasks the U.S. Chairman of the Joint Chiefs of Staff (CJCS) to provide military support to the democratic movement in order to bring freedom to the Burmese people. The desired end state is a freely elected, pro-democracy Burmese government that increases security of the Malaccan Strait, combats terrorism, and stems the flow of opium.

9.3 Mission

Based on this guidance, the U.S. CJCS directed Commander, U.S. Pacific Command (PACOM) to:

1. Form a Combined Joint Task Force (CJTF) to:
    a. Keep the Straits of Malacca open to the free movement of commercial shipping by neutralizing the Burmese naval activity in and around the straits.
    b. Protect and support the pro-democracy forces in Bhamo and Tavoy.
2. Prepare plans for a large-scale operation to defeat the Burmese military regime.
3. Prepare proposed response options and/or contingency plans needed to deter Chinese and/or Indian intervention.
4. Monitor Chinese and Indian force locations and behavior.

The commander of the new CJTF 140, Vice Admiral Hues, has issued the following guidance:

The Joint Force Land Component Commander (JFLCC), Army Brigadier General Allwell, is responsible for supporting the rebels in Bhamo. His

concept of operations involves inserting at least one airborne division directly into the Bhamo region. Due to the political sensitivities of having US forces in close proximity of China and India, the U.S. is conducting diplomatic discussions with those countries. The Bhamo operations and associated forces are on alert, pending resolution of the diplomatic efforts. Despite Thailand's support as an ASEAN member, they have been reluctant to grant basing and overflight rights to the U.S. forces. This reluctance stems from their increased ties with the Chinese economy and a desire to keep the conflict from spilling into their country. Once basing is granted, a U.S. Army combat aviation brigade and an airborne division will be deployed to Bhamo and sustained by the Air Mobility Command (AMC) from the Thai airbase at Chiang Mai.

The Joint Forces Maritime Component Commander (JFMCC), Rear Admiral Sheradie, is responsible for keeping the Straits open and supporting the forces in Tavoy. Operation Piranha Treasure (OPT) will keep the Straits open. Operation Burmese Sanctuary (OBS) will support the rebel forces in the south by rapidly deploying 2 Carrier Strike Groups (CSG) and 2 Expeditionary Strike Groups (ESG) to the northern Andaman Sea. These forces will establish air and sea dominance, providing a Sea Shield for the operations south of Moulmein. The special operations elements of the 2 Marine Expeditionary Units (MEU) Special Operations Capable (SOC) in the ESGs will interdict lines of communication south of Moulmein to slow Burmese deployment south. If the Burmese give indications of launching an offensive to the south, both full MEUs will deploy in and around Moulmein as a blocking force. In the Tavoy area, the JFMCC will conduct Forcible Entry Operations to take control of the Tavoy airfield and Tavoy port facility. Brigadier General Allwell provides 2 support battalions for the operation. Marine Brigadier General Mizlic, the Marine Component Commander, provides 3 Battalion Landing Teams (BLT) and the supporting forces at the Sea Base. This Joint Expeditionary Brigade (JEB) is to secure Tavoy. Once the JEB secures Tavoy, it will support rebel actions to establish control south of Moulmein.

9.4 Current Situation

It has been two days since the freedom fighters have captured Bhamo and Tavoy. The military regime's forces are mobilizing for larger actions and are expected to launch an offensive south toward Tavoy within the next 7 to 10 days. Time is critical.

9.5 Geography

Burma, shown in Figure 9-2, is a vast country with poorly developed transportation infrastructure. The tropical low lands near the coast transition quickly into rugged foothills and mountains. Numerous waterways cross the lowlands, making bridges critical infrastructure. The long coastline includes large river deltas, countless small bays and inlets, coastal islands, and long, sandy beaches. See Enclosure 1 for more information on Burma.

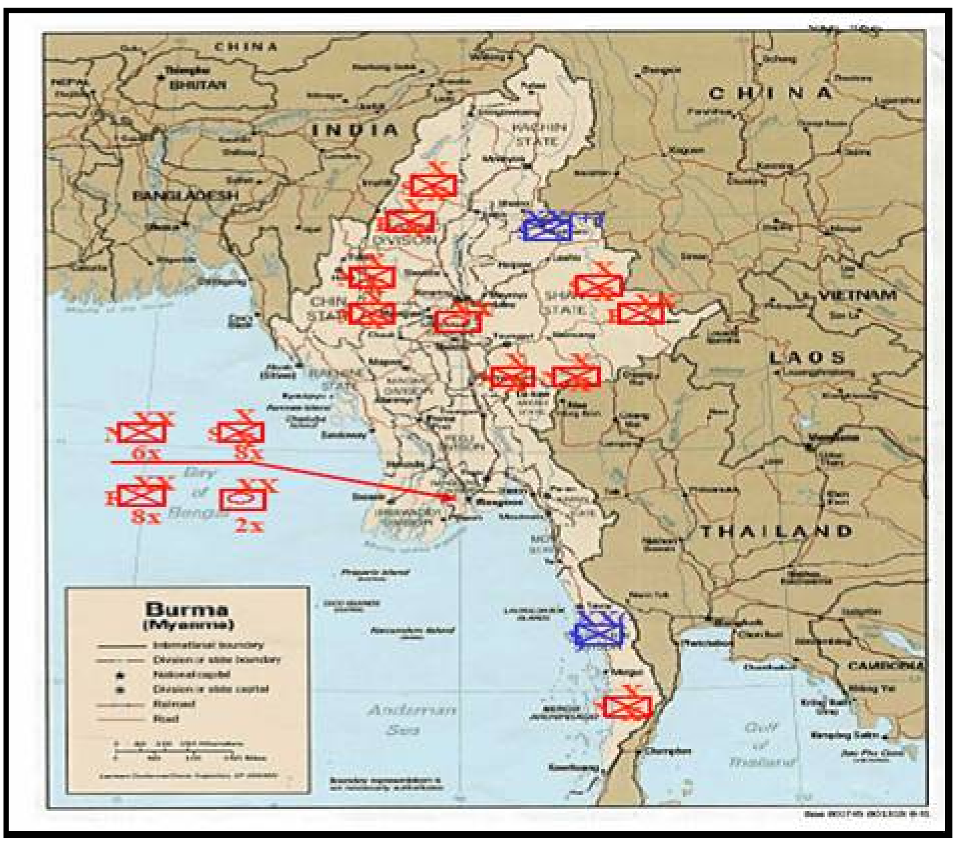

Figure 9-2: Map of Burma with Coalition, Rebel, and Key Enemy Positions (Burma Star Association, 1991).

9.6 Enemy Order of Battle

The Burmese National military has a large army. However, 20% of the 400,000-man army is comprised of children under the age of 17. Much of the army is poorly trained, widely dispersed, and has little experience in coordinated warfare. The Burmese Air Forces, including missile forces, exist to defend Rangoon. Their Naval Forces focus on regional defense and coastal patrol.

9.6.1 Enemy Land Forces

The Burmese National Land Forces include infantry units, armor units, and Special Forces units as described below:

- 12 Light Infantry Divisions (LIDs): There are 12,000 troops per division. The LIDs comprise the majority of Burmese units. The weapons and equipment include multiple launch rocket system (MLRS), 122mm howitzers, trucks, SA-18s, and RPG-12s. These troops are motivated by pay and pride.

- 13 State Infantry Divisions (State IDs): There are 12,000 troops per State ID. The weapons and equipment order consists of 122mm mortars. The State IDs have moderate offensive capability, and most of the units are made up of conscripts. Troops in the State IDs are motivated by the right to plunder rebel territories.

- 12 Regional Infantry Divisions (Regional IDs): There are 9,000 troops per division. The weapons and equipment order consists of 122mm mortars. The Regional IDs have little offensive capability and are made up of mostly local conscripts and children. The troops of the Regional IDs are under local command.

- 3 Armored Divisions: These are equipped with 400 Chinese-built armored personnel carriers (APCs), 80 Chinese tanks, MLRS, and 122mm howitzers.

- 4 Special Forces Bureaus: These SOF units conduct intelligence gathering and strategic strike operations. The troops are highly motivated. These SOF units more closely resemble the Nazi Gestapo than the U.S. Delta Force.

These Burmese Army units are deployed as follows (see Figure 9-2):

- Four elite Light Infantry Divisions and 5 State Infantry Divisions stationed in and around Rangoon.
- Two Armored Divisions, 2 Light Infantry Divisions, and 3 State Infantry Divisions based in Kyunchaung near the Three Pagodas Pass on the Isthmian border with Thailand.
- One Special Forces Bureau and a Light Infantry Division based near the Amya Pass on the Isthmian border with Thailand.
- Three Light Infantry Divisions, 3 State Infantry Divisions, and 1 Armored Division based in Ngape in western Burma.
- A strategic task force of 2 Light Infantry Divisions, 2 State Infantry Divisions, and 2 Special Forces Bureaus headquartered in Mandalay.
- Eight Regional Divisions are scattered along Burma's eastern border with Thailand.
- Four Regional Divisions are scattered along Burma's northwestern border with India.

9.6.2 Enemy Air Forces

The military regime centers its Air Forces on Rangoon. Airfields outside Rangoon base only transport and patrol aircraft. This Air Force includes:

- 1 Air Defense Artillery (ADA) Wing: This unit consists of modern, Chinese-made, medium-altitude missile systems, numerous SA-18s, and

numerous antiquated cannons integrated with radar and communication systems.

- 1 Fixed Air Wing: This unit consists of 3 intercept aircraft, 6 attack aircraft, 1 troop transport plane, and 2 surveillance squadrons. The attack aircraft are capable of carrying anti-ship missiles.
- 1 Rotary Air Wing: This unit consists of 3 observation/utility helicopter squadrons and 3 modern (Bell) attack helicopter squadrons with Israeli anti-tank guided munitions (ATGMs).

9.6.3 Enemy Naval Forces

The Burmese National Naval Forces include destroyers, frigates, missile patrol boats, coastal patrol boats, and riverine craft. The Navy also maintains and deploys mobile anti-ship missile batteries. A Naval Special Forces Bureau is used to interdict sea-borne traffic flow through the waterways of Southeast Asia. These Naval Special Forces have been posing as pirates in small, fast patrol craft armed with hand-launched and base-mounted missile systems. Intelligence suggests that these forces established headquarters in the port city of Myeik; the actual vessels are scattered around the islands of the Merguis Archipelago close to the western entrance of the Straits of Malacca. Despite international protests, they have conducted exercises within Indonesian, Thai and Malaysian territorial seas. These forces number approximately 200-300 specially trained personnel operating 30-50 watercraft. According to some sources, the watercraft may also have limited mine deployment capability. In addition to these forces, the Burmese West Coast Fleet, based in Akyab (Sittwe), is comprised of 1 Luhai DDG, 2 Jiangwei FFGs, 5 Hainan-class coastal patrol craft, and 5 Houxin-class missile boats. The rest of the fleet deploys from Moulmein (Mawlamyine). The Burmese use these more conventional forces to protect their territorial seas and support the so-called pirates of the Naval Special Forces. The Naval order of battle includes:

- 1 LUHAI DDG
- 2 JIANGWEI FFGs

- 5 HAINAN-Class Coastal Patrol Craft
- 5 HOUXIN-Class Missile Boats
- 20-30 Coastal Patrol Boats: These patrol boats are capable of mine laying, seizure of merchant vessels, and employing hand-held SAMs.
- 90 Riverine Craft: Small arms capable.
- 5 Coastal Batteries: One fixed site south of Rangoon and four mobile batteries. Each battery carries 12 missiles. Each missile has an effective range of over 200 NM. Two mobile batteries of 320mm rocket cannons (6 cannons per battery). Each rocket has an effective range of over 120 NM. All of these systems need external, over-the-horizon targeting from either ships or aircraft.

9.6.4 Enemy Early Warning Forces

Intelligence also reports possible electronic stations manned by the Chinese in facilities along the Bay of Bengal coastline, the Cocos Islands near the Preparis South Channel, and Lord Loughborough Island and Great Western Torres Island in the Mergui Archipelago in the Andaman Sea (Cole, 2001).

9.7 Burma Scenario Threat Analysis

This section analyzes the threat to the Sea Base. Pertinent threats are converted into a probability of kill (Pk) used to model the threat. Per the JELo Operating Concept [Chapter 2], SEA-6 assumes that the Sea Shield is established in the Andaman Sea prior to the Sea Base closing for the assault. This threat analysis focuses on the Burmese subsurface, surface, air, and land threats to a Sea Base, specifically to the Maritime Pre-positioning Group (MPG) of the Sea Base.

9.7.1 Mines

Burma has not employed free-floating mines in deep water because of the threat posed to their own naval vessels and the extreme negative publicity.

9.7.2 Torpedoes

Burma has not yet acquired their desired submarine capability. The torpedo threat to the MPF(F) comes from the Burmese combatants and from small commercial boats. Burma practices to employ swarm tactics. The Sea Shield assets are able to keep the Burmese combatants and commercial small boats out of torpedo range of the MPF(F). Pk for torpedo threat to MPF(F) is assumed to be 0.

9.7.3 Anti-Ship Cruise Missiles (ASCM)

Burmese anti-ship cruise missiles threaten the Sea Base. With a 1,000-ft length, 200-ft beam, and 50-ft freeboard, the MPF(F) unconstrained ship [Chapter 5] is a large target. The MPF(F) does not have missile-defense systems. Built to commercial cargo ship standards, its limited damage control capability make it unlikely that the MPF(F) will survive even a single ASCM hit.

9.7.4 Air-Launched ASCM

With Sea Shield in place, the airspace is secure from manned aircraft threat. The air-launched ASCM threat is assumed to be 0.

9.7.5 Shore-Launched ASCM

Three mobile SSM batteries are deployed and unlocated, each with 12 missiles per battery. Each missile has a 200 NM effective range. One mobile battery of 320mm rocket cannons is deployed and unlocated. Six cannons, each with a range of 120 NM, comprise the battery. The ASCM risk increases as the MPF(F) gets closer to the shore; however, it is still acceptable because the Burmese have only limited over-the-horizon-targeting capability.

9.7.6 Ship-launched Anti-ship Cruise Missiles

The Sea Shield combatant ships maintain a maritime keep out zone and a defensive perimeter around the MPG.

9.7.7 Air-Delivered Weapons

Sea Shield establishes air superiority prior to Sea Base establishment. The air defense portion of Sea Shield detects and engages incoming threats out beyond 200 NM from the Sea Base.

9.8 Threats to Surface Assault Connectors

The threat window period exists from when the surface assault connectors are in transit between the Sea Base, the beach, and back. The following sections address the threats in this window.

9.8.1 Mines

The long Burmese coastline precludes them from effectively mining everywhere. However, the military regime does have enough mines and mine-capable vessels to effectively mine a small passage, an inlet, or a single beach. The Burmese have only bottom and moored mines, which are most effective in straits, inlets, or on anticipated landing beaches. JFMCC assumes that the Burmese have mined the assault beach at Tavoy and the inlet to the Tavoy River.

9.8.2 Torpedoes

Torpedoes pose little threat to the hovercraft assault connectors because of their high speed and shallow draft. Although torpedoes do pose a threat to displacement surface-assault connectors (LCU(Rs), etc.), their high speed and maneuverability make them a difficult torpedo target. Therefore, the probability of kill (P_k) for torpedoes against the surface assault connectors is assumed to be 0.

9.8.3 Beach Obstacles

Burma's long coastline and the CSG activity to the North make it difficult for the Burmese to decide which beach to defend. By the time the Burmese obtain actionable intelligence on the proximity of the MPG, (1-2 days out when the MPG is detected by the Coco Island listening station), they will have insufficient time to deploy obstacles to the likely landing sites.

9.8.4 Surface Threats

Once the MPG closes to 25 NM to initiate the assault, the attack helicopters from the JEB Air Combat Element (ACE) will provide defense to the surface assault connectors from patrol boat-like combatants and or civilian craft.

9.8.5 Air Threat

Both the CSG regional air superiority and the MPG's ACE reduce the air threat to the assault connectors to near 0.

9.8.6 Surface Assault Threat Model Inputs

SEABASE-6 models the Burmese threat using the analysis from the SEI-3 Final report.[240] The 2015 BLA brings some organic Mine Counter Measure (MCM) capability in the SH-60 and CH-53X (if configurable as MH-53s). These measures and the mine warfare capabilities of the ESG and CSG (LCS with a MIW mission module) reduce the SEI-3 P_k value from 0.07 to 0.03. The full mission probability of kill for a surface assault connector is calculated using the circulation model in Figure 9-2.

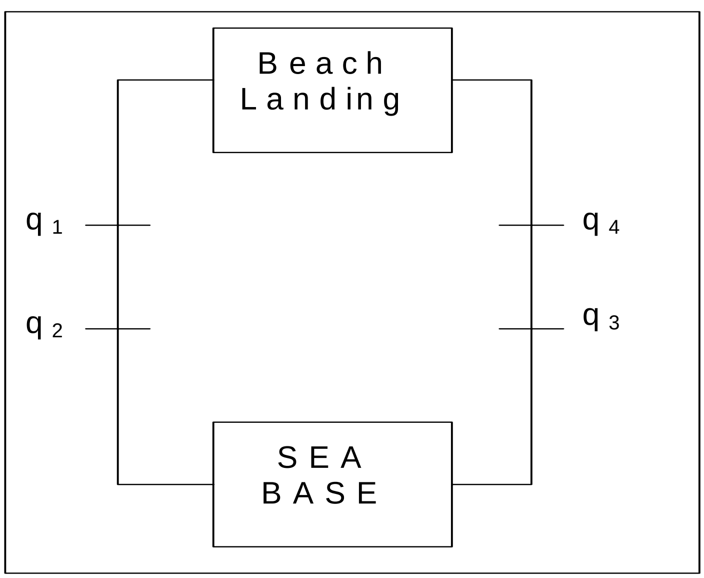

Figure 9-2: SEI-3 Surface Assault Connector Circulation Model.[241]

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[240] SEI-3 Final Report, Chapter VI, pp. 47-54.
[241] Operations Research Department, "Joint Campaign Analysis Book 1 – Student Text," unpublished student text, Naval Postgraduate School, Monterey, CA, 1999.

$q_1 = q_4$ = Probability of Survival for a surface connector hitting a mine

Probability of Kill for an assault connector hitting a mine

$P_{k1} = 0.03$[242]

$q_1 = 1 – P_{k1} = 1 – 0.03 = 0.97$

$q_2 = q_3$ = Probability that a surface connector survives an anti-ship missile attack

$q_2 = 0.99$[243]

Half-Mission Survivability:

$q = q_1 * q_2 = 0.97 * 0.99 = 0.96$

Half-mission Probability of Kill:

$P_k = 1 – q = 1 – 0.96 = 0.04$

Full-Mission Survivability:

$q * q = q^2 = (0.96)^2 = 0.92$; therefore,

Full-Mission Probability of Kill:

$P_k = 1 – q^2 = 1 – 0.92 = 0.08$

9.9 Threats to Air Assault Connectors

Despite the best work of Sea Shield, the mobile SAM, AAA, and MANPADS systems will still pose a threat to the air assault connectors. As the operation proceeds, Suppression of Enemy Air Defenses (SEAD) assets target and destroy threat sites. However, air connectors' routes will become more predictable, causing the risk to increase. These two effects offset each other. Therefore, the P_k against the

242 This value calculated from a Burma analysis done for the Spring Joint Campaign Analysis class.
243 Ibid.

air assault connectors is a constant value. The P_k value is the same that SEA-6 uses in their 2004 Joint Campaign Analysis Mini Study of Burma. In both that study and this one, the overall P_k is calculated using the circulation Model[244] in Figure 9-3.

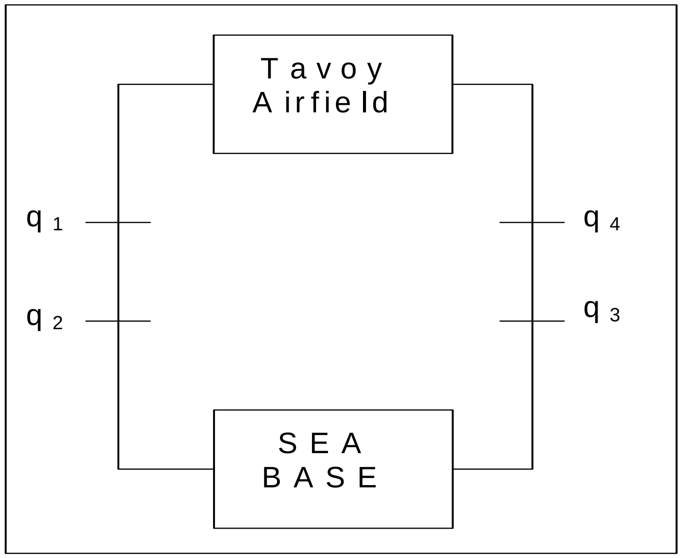

Figure 9-3: Air Connector Circulation Model.

$q_1 = q_4$ = Probability air connector survives Surface-to-Air Missile Attack

$q_2 = q_3$ = Probability air connector survives AAA Attack

Half-Trip Survivability:

$q = q_1 * q_2$ where $q_1 = q_2 = 0.99$[245]

$q = 0.99 * 0.99 = 0.98$

Half-Trip Probability of Kill:

$P_k = 1-q$

$P_k = 1 - 0.98 = 0.02$

Roundtrip Survivability and Probability of Kill:

$q * q = q^2 = (0.98)^2 = 0.96$ therefore;

$P_k = 1 - q^2 = 1 - 0.96 = 0.04$

That is, an air assault connector will be shot down on average 4 out of 100 trips to the beach.

[244] Ibid.

[245] SEI-3 Final Report, Chapter VI, p. 35.

9.10 Threats to Land Forces

Another threat window to the land forces starts when they disembark from their assault connectors. For air-delivered troops, the P_k estimate averages across all casualty mechanisms (mines, artillery, hostile fire, etc.). Surface-delivered troops move by vehicle to the objective area. Once the surface assault connectors are ashore, the P_k for the delivered troops switches to a value based on vehicle losses. Once at the objective area, the troops "dismount" their vehicles. A similar, but slightly different, P_k is used for the dismounted troops.

9.10.1 Attrition of Dismounted Troops

The combined effects of enemy fires (direct and indirect), land mines, and booby-traps wound dismounted troops. The rate of attrition is highly dependent on the relative number of friendly and enemy troops. Wounded-in-Action casualties drive the number of medical evacuation missions required. Based on the MAGTF Planner's Guide Casualty Rates,[246] the casualty rates vary with the level of combat and numbers of troops ashore. To decrease complexity, an average rate is used with values of –three wounded per hr during employment and –one wounded per hr during sustainment. Enclosure 2 shows an off-line troop casualty estimate performed using the MAGTF Planner's Guide. The SEABASE-6 simulation results agree within 5%-10%.

9.10.2 Attrition of Ground Vehicles

Ground vehicles attrite from the combined effects of Burmese fires (direct and indirect), mines, Improvised Explosive Devices, vehicle accidents, and malfunctions. Ground vehicle attrition is estimated from the number of vehicles lost per day during Operation Iraqi Freedom from May-September 2003[247] [Enclosure 3]. Vehicle attrition rate uses both combat losses and vehicle accidents. This data gives an average of 0.5 vehicles per day or 0.02 vehicles per hr.

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[246] MAGTF Planner's Reference Guide, p. 73.
[247] www.militarycity.com, November 2004.

9.11 Combat Level

At each time step, the model stochastically assigns the combat intensity level to the operation ashore (high or low). The level chosen determines which consumption rates the model uses during that time step. The USMC defines their consumption rates as Assault for high intensity combat and Sustain for low intensity combat[248] and this section repeats that naming convention. Enclosure 4 describes the process and calculation that produces the following distributions.

JEB employs before day 10:

Probability of Assault Combat Level = 0 for $0 \le$ time ≤ 10 days
0.42 for 10 days $\le$ time $\le$ 20 days
0.37 for 20 days $\le$ time $\le$ 30 days

JEB employs after day 10:

Probability of Assault Combat Level = 0 for $0 \le$ time ≤ 10 days
0.95 for 10 days $\le$ time $\le$ 20 days
0.05 for 20 days $\le$ time $\le$ 30 days

9.12 CONUS Readiness Delay

The troop's mobilization delay is modeled as a uniform distribution from 24 hrs to 96 hrs.

9.13 Forward Deployed Forces Delays

Forward deployed forces (ESG, CSG, MPF(F)) are assumed to be at a higher state of readiness than those in CONUS. A uniform distribution models this 24- to 48-hr mobilization delay. The response delay of the forward-deployed forces is modeled as a uniform distribution from 24 hrs to 48 hrs. The smaller time interval reflects the increased readiness of deployed forces. The forward deployed forces are assumed to be operating in the Indian Ocean. The time distance calculations from the Indian Ocean to the AO have the arrival of the ESG and CSG in five to six days. Their early arrival allows them to employ their organic mine countermeasure assets to clear lanes for the beach assault.

[248] MAGTF Planner's Reference Guide, Part V, p. 73.

9.14 Distances

Enclosure 5 shows the closure times for forces transiting from appropriate ports to Burma Joint Operating Area (JOA). The pertinent distances from the scenario are:

From Okinawa to Burma = 5,800 NM
Sea Base Position to Chaungwabyin Beach = 110 NM
Chaungwabyin Beach to Tavoy = 40 NM by road
Sea Base Position to Tavoy = 150 NM
Diego Garcia to Sea Base Position = 2,000 NM

9.15 Ground Vehicle Utilization Rates

Given the small overland ranges of the scenario, ground vehicle usage is 50%. Each ground vehicle is on and running 12 out of every 24 hrs of the operation.

Enclosure 1: CIA World Fact Book summary of Burma

Burma	Geography
Location:	Southeastern Asia, bordering the Andaman Sea and the Bay of Bengal, between Bangladesh and Thailand
Geographic coordinates:	22 00 N, 98 00 E
Map references:	Southeast Asia
Area:	*total:* 261,995 sq mi *land:* 253,978 sq mi *water:* 8,016 sq mi
Area - comparative:	slightly smaller than Texas
Land boundaries:	*total:* 3,651 mi *border countries:* Bangladesh 120 mi, China 1,358 mi, India 909 mi, Laos 146 mi, Thailand 1,118 mi
Coastline:	1,199 mi
Maritime claims:	*contiguous zone:* 24 NM *continental shelf:* 200 NM or to the edge of the continental margin *exclusive economic zone:* 200 NM *territorial sea:* 12 NM
Climate:	tropical monsoon; cloudy, rainy, hot, humid summers (southwest monsoon, June to September); less cloudy, scant rainfall, mild temperatures, lower humidity during winter (northeast monsoon, December to April)
Terrain:	central lowlands ringed by steep, rugged highlands

Elevation extremes:	*lowest point:* Andaman Sea 0 ft *highest point:* Hkakabo Razi 19,295 ft
Natural resources:	petroleum, timber, tin, antimony, zinc, copper, tungsten, lead, coal, some marble, limestone, precious stones, natural gas, hydropower
Land use:	*arable land:* 15% *permanent crops:* 1% *permanent pastures:* 1% *forests and woodland:* 49% *other:* 34% (1993 est.)
Irrigated land:	4,124 sq mi (1993 est.)
Natural hazards:	Destructive earthquakes and cyclones; flooding and landslides common during rainy season (June to September); periodic droughts
Environment - current issues:	deforestation; industrial pollution of air, soil, and water; inadequate sanitation and water treatment contribute to disease
Environment - international agreements:	*party to:* Biodiversity, Climate Change, Desertification, Endangered Species, Law of the Sea, Nuclear Test Ban, Ozone Layer Protection, Ship Pollution, Tropical Timber 83, Tropical Timber 94 *signed, but not ratified:* none of the selected agreements
Geography - note:	Strategic location near major Indian Ocean shipping lanes

Geographical Statistics for Burma (Source: CIA, 2001).[249]

[249] http://www.cia.gov/cia/publications/factbook/geos/bm.html, December 2004.

Enclosure 2: Troop CASUALTY Estimates

Troop Attrition Rates if JEB employs before 10 days

The values in the table come from MAGTF Planner's Guide for a moderate ground campaign and a light air campaign. The units for the values in the table are (per thousands per day); the values that have parentheses around them have the units of (total force per day).

	Blue	Blue and Rebels	Red
Killed in Action	4	5	20
Wounded in Action	16	21	36
Died of Wounds	1	1	5
Disease Casualties	7	7	9
Non-battle Injuries	1	2	3
Battle Fatigue	1	2	5
Missing in Action	1	1	1
Captured	1	1	1
Admin Losses	0	0	0
Total	32 (156)	40 (275)	80 (572)

Troop Attrition Rates if JEB employs after 10 days

The values in the table come from MAGTF Planner's Guide for a heavy ground campaign and a heavy air campaign. The units for the values in the table are (per thousands per day); the values that have parenthesis around them have the units of (total force per day).

	Blue	Blue and Rebels	Red
Killed in Action	16	20	40
Wounded in Action	62	79	74
Died of Wounds	2	2	10
Disease Casualties	8	12	10
Non-battle Injuries	2	3	3
Battle Fatigue	4	5	7
Missing in Action	1	1	1
Captured	1	1	1
Admin Losses	0	0	0
Total	96 (467)	123 (844)	146 (1044)

Enclosure 3: Ground Vehicle losses during Operation Iraqi Freedom February-September 2003[250]

Month	Vehicles Lost Combat	Vehicle Accident Casualties	Total Vehicles Lost Combat + Accidents	Total Vehicle-related Casualties
May	4	6	10	12
June	1	4	5	5
July	14	3	17	19
Aug	11	4	15	14
Sep	5	3	8	8
Oct	15	2	17	17
Nov	18	3	21	24
Dec	12	5	17	20
Jan	6	1	7	13
Feb	3	2	5	8
Mar	7	4	11	18
Apr	15	1	16	20
May	16	6	22	20
June	4	1	5	10
July	10	7	17	16
Aug	7	2	9	9
Sep	8	4	12	11
Total	156	58	214	244
Mean	9	3	13	14
Std Dev	5	2	6	5
Per Day	0.3	0.1	0.5	0.5

[250] www.militarycity.com/valor/honor, 27 November 2004.

Enclosure 4: Combat Level Calculations

This calculation assumes that troop levels determine combat intensity; the more troops at the objective, the higher the probability of being in high intensity combat. SEABASE-6 assigns a simulation combat level from a probability distribution. This distribution is determined using the following steps:

1. Determine the per thousand troops per day losses for the Blue and Red forces using the MAGTF Planner's guide method.
2. Determine force losses for all Blue and Red forces per day.
3. Determine the losses for Blue and Red forces over 30 days.
4. Perform a linear regression on the data points determined in Step 3. Where the independent variable is the day of the operation and the dependent variable is the surviving troops.
5. To determine the combat intensity, the area under the curve was calculated. This was done by dividing the time into wedges (JEB arriving < 9 days: 0-9, 9-28, 28-39, 39-49 days and JEB ≥ 10 days: 0-10, 10-20, 20-30 days) and then dividing the area under the wedge by the entire area under the curve. All negative are ignored since you cannot attrite more than you have.

Repeating this process twice reflects the change in force accumulation with time. The first calculation is for the JEB arriving at the objective in less than 9 days. In less than 9 days, the opposing Burmese force in Tavoy is smaller and less effective. The process is repeated to reflect the JEB arriving after 10 days. After 10 days, the opposing Burmese force is massed and prepared for the attack.

The equation, derived from the MAGTF Planner's Guide, that appears in the first row of the two following tables estimates wounded soldiers as a function of soldiers present. The remaining rows show the probability estimate from the process described above.

	Blue	Blue and Rebels	Red
Equation	# of Blue Forces Remaining = –155 (day) + 6,258	# of Blue and Rebel Forces Remaining = –254 (day) + 9,143	# of Red Forces Remaining = –63 (day) + 12,182
Day 0-9	0	0	0
Day 9-28	.4241	.4500	.7746
Day 28-39	.3739	.3754	.2254
Day 39-49	.2020	.1746	0
Total	1.0000	1.0000	1.0000

Combat-level probabilities if JEB arrives in less than 9 days.

	Blue	Blue and Rebels	Red
Equation	# of Blue Forces Remaining = –466 (day) + 9,524	# of Blue and Rebel Forces Remaining = –816 (day) + 15,021	# of Red Forces Remaining = –030 (day) + 17,417
Day 0-10	0	0	0
Day 10-20	.9463	1.000	1.000
Day 20-30	.0537	0	0
Total	1.0000	1.0000	1.0000

Combat-level probabilities if JEB arrives in 10 days or more.

- Day 0 is defined as the day that the Deployment Order is released.
- From Day 0-9 troops are in transit and are not in contact with hostile forces; therefore, the probability that they engage hostile forces is 0.
  - ➢ This is 0 because all of the enemy attacking forces are dead. Therefore, the 7,144 men assigned to red forces cannot attack. (The other values in the row are not 0 because of leftover Improvised Explosive Devices (IEDs), mines, etc.)
- From Day 0-10 troops are in transit and are not in contact with hostile forces; therefore, the probability that they engage hostile forces is 0.
  - ➢ This is 0 because all of the enemy attacking forces are dead. Therefore, the 6,859 men assigned to red forces cannot attack. (The other values in the row are not 0 because of left over IEDs, mines, etc.)

Enclosure 5: Closure Times for the Burma Scenario

	Tavoy NM	5 KTS HRS	10 KTS HRS	15 KTS HRS	20 KTS HRS	25 KTS HRS	30 KTS HRS	35 KTS HRS	40 KTS HRS
Singapore	1,117	223.4	111.7	74.5	55.9	44.7	37.2	31.9	27.9
Diego Garcia	2,052	410.4	205.2	136.8	102.6	82.1	68.4	58.6	51.3
Indian Ocean	3,000	600.0	300.0	200.0	150.0	120.0	100.0	85.7	75.0
Sasabo, Japan	3,545	709.0	354.5	236.3	177.3	141.8	118.2	101.3	88.6
Guam	3,698	739.6	369.8	246.5	184.9	147.9	123.3	105.7	92.5
Yokosuka	3,999	799.8	399.9	266.6	200.0	156.0	133.3	114.3	100.0
Honolulu	6,994	1398.8	699.4	466.3	349.7	279.8	233.1	199.8	174.9
San Diego	8,858	1771.6	885.8	590.5	442.9	354.3	295.3	253.1	221.5
Indian Ocean	3,000	600.0	300.0	200.0	150.0	120.0	100.0	85.7	75.0

10. 2015 BASELINE ARCHITECTURE CAPABILITY GAPS

10.1 Overview

The culminating product of the Functional Needs Analysis (FNA), as discussed in the Methodology section of Chapter 1, is a description of the capability gaps between the requirements identified in the Functional Area Analysis (FAA) [Chapter 3] and the performance of the 2015 Baseline Architecture (2015 BLA). This chapter analyzes the 2015 BLA capability gaps. Previous studies identify many of the gaps in Sea Base Logistics (e.g., the need for heavy vertical lift capacity), but do not always quantify these gaps. The extent of these gaps depends heavily on the assumed architecture and operating conditions. The gaps this analysis identifies are specific to the chosen scenario, architecture, and assumptions made in this study. However, the insights into system behavior may be more general.

The purpose of the 2015 BLA analysis is to identify and quantify capability gaps, and to document the architecture's behavior. Although this chapter addresses the 2015 BLA, the same analysis is applied to the 2025 Alternative Architectures described in Chapter 12. As mentioned in Chapter 1, this study covers the Closure, Assembly, Employment, and Sustainment Phases of operations.

The Joint Expeditionary Logistics (JELo) requirements of Chapter 3, when stated as questions, become the 2015 BLA's Critical Operational Issues (COIs).[251] Appropriate Measures of Effectiveness (MOEs) and Measures of Performance (MOPs) provide a means to answer these questions. The SEABASE-6 model, described in Chapter 8, models the scenario variables to obtain the data described here.

[251] Hoivik, Thomas H., OA-4603 Test and Evaluation Lecture Notes, Version 6.0, (Naval Postgraduate School, Monterey, CA, 2004).

10.2 Measures of Effectiveness and Performance

The JELo MOEs and MOPs listed in Enclosure 1 are used because they are:[252]

- quantitative;
- measurable or estimable;
- directly related to the objective; and
- reflective of the benefit/penalty of an alternative.

Enclosure 1 lists all of the COIs, MOEs, and MOPs developed for this analysis. This discussion contains only those COIs that provide high-level insights into system performance, although multiple measures provide insight into specific processes and subsystems within the architecture.

10.3 Modeling the 2015 Baseline Architecture

SEA-6 created a model using Extend™ software that simulates the 2015 BLA's performance and behavior. The SEABASE-6 model is described in detail in Chapter 8. The model initial conditions, internal characteristics, and external factors influence the architecture performance, and hence the experiment's outcome.

10.3.1 Model Initial Conditions

These variables define the starting simulation conditions. They include the ranges from the United States to the Forward Logistics Site (FLS), the FLS to the Sea Base, and the starting position of the Maritime Prepositioning Force (Future) (MPF(F)), Expeditionary Strike Group (ESG), and Carrier Strike Group (CSG). For the simulation, the prepositioning site for the MPF(F) is the FLS. Appendix B contains the complete description and listing of these variables.

[252] Kline, Jeff E., "Measures of Effectiveness," unpublished lecture notes for the NPS OS3680 Naval Tactical Analysis Course, 30 September 2003.

10.3.2 Architecture Internal Variables

The internal variables (e.g., speed, capacity, transfer time, etc.) describe the subsystems, components, interfaces, and relationships that make up the architecture. The collection of these variables defines the architecture in the model. SEA-6 functional subsystem teams perform research and off-line analysis to generate the values of these variables. Appendix B lists these internal variables for the 2015 BLA.

10.3.3 External Factor Variables

These external variables represent the primary factors external to the architecture that act on the entire system and significantly influence its overall performance. The external factors evaluated in this experiment are sea state, level of combat (consumption rates), range (Sea Base to shore), and range (shore to objective). These four factors reflect significant operational concerns of a Joint Task Force Commander and are important design drivers for multiple Sea Base logistics architecture components. Table 10-1 lists the external factors and their corresponding levels evaluated.

EXTERNAL FACTORS			
Sea State	**Level of Combat**	**Range, Sea Base-to-Shore (NM)**	**Range, Shore-to-Objective (NM)**
2	Sustain	25	10
3	Assault	40	50
4	—	100	100

Table 10-1: Simulation Experiment External Factors and Levels.

Sea state values of 2, 3, and 4 represent the most common ocean conditions. The level of combat values, assault and sustained, are how the USMC represents sustainment planning factors for food, water, fuel, and ammunition.[253] The SEABASE-6 model uses these published USMC planning factors for consumption rates and casualty rates. Ranges are the distances (in NM) between the Sea Base, shore, and objective. The two different range variables affect different parts of the architecture. The range from Sea Base to shore directly impacts the performance of the surface assault connectors and determines the threat posed to the MPF(F). The range from shore to objective impacts

[253] Marine Corps Combat Development Command, “MAGTF Planner’s Reference Manual,” April 2001, (U.S. Marine Corps MSTP Center (C 54) MCCDC, Quantico, VA, 20 April 2001), Part IV.

the performance of the ground distribution system (trucks, Humvees, etc.) and vertical sustainment. The sum of the two ranges is the one-way distance (radius) that the air assault connectors travel. The range values in Table 10-1 are used because they cover most of the total range envelope (25 NM to 200 NM) prescribed in the FAA [Chapter 3]. Figure 10-1 shows the coverage that the nine unique combinations of Range 1 and Range 2 give of the total range envelope.

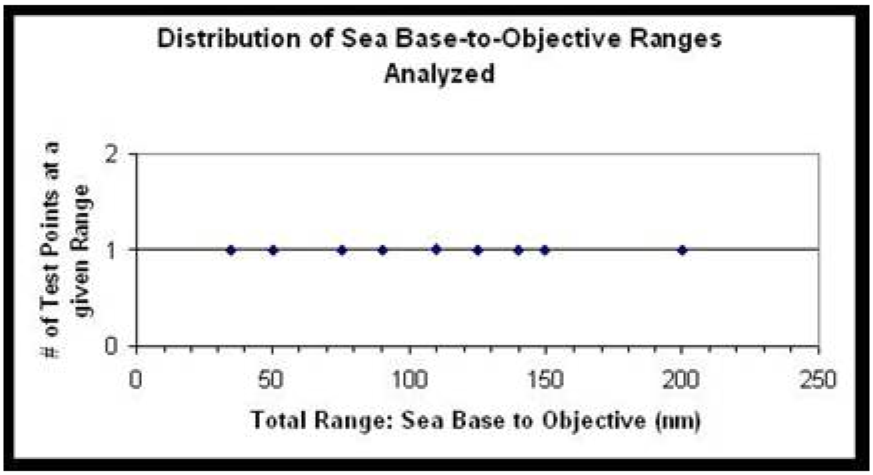


Figure 10-1: Sea Base to Objective Ranges Resulting from Range Combinations.

Enclosure 2 lists the full factorial trial matrix. For example, Run #1 is for sea state 2, sustaining level of combat, 25 NM from Sea Base to shore, and 10 NM from shore to Sea Base (total range of 35 NM Sea Base to Objective).

10.4 Simulation Experiment

The Burma Scenario simulation in Chapter 9 generates the architecture performance data. Additionally, a full-factorial simulation experiment generates insight into architecture behavior and assesses external factor interactions. Both the scenario simulation and the factorial experiment use 30 replications per run to produce a robust data sample. Using both Microsoft Excel™ and MINITAB 14™ software, the model output data is analyzed to determine if the architecture's performance meets the requirements specified in the FAA [Chapter 3]. Where the architecture does not meet the requirement, further analysis quantifies the capability gap and assesses the likely causes of the capability gap.

10.4.1 Scenario Simulation

SEA-6 measures the architecture's performance by simulating a Joint Expeditionary Brigade (JEB) deployment to Burma. The scenario variables reflect the variability of real-world operations. For example, the level of combat varies randomly based on a time-phased distribution and the sea state values vary randomly based on real oceanographic data for the Andaman Sea.

10.4.2 Full Factorial (Factor Effects and Interactions)

The full factorial experiment design determines the external factor effects and the interactions among the external effects. Each observation estimates an effect from each primary factor listed in Table 10-1. Limiting the experiment to only 2-3 levels per factor reduces the overall number of experiment trials, a necessary trade-off between simulation run time (approximately 2-3 minutes per replication) and the amount of insight gained.

10.4.3 Capability Gap Analysis

As mentioned, the 2015 BLA's capability gaps are identified based on performance during the Burma Scenario simulation. The ratio of the number of runs that meet the requirements over the total number of runs (30) represents the probability of meeting the requirement. A one-sided t-test (at a 10% significance level) determines if the mean value of each MOP meets its associated requirement. C-day, the day the deployment order says to move out, and L-hour, the hour that deployment begins, are used to express the performance requirements.[254] Enclosure 3 shows the calculation of the critical times that must be achieved to meet the timeline requirements. Further analysis determines the cause(s) of any statistically significant gaps. Full factorial data and queuing data from the SEABASE-6 model aid this analysis.

10.4.4 External Factor Effects and Factor Interaction Analysis

The full factorial data, reduced via MINITAB 14™, highlights external factor effects and factor interaction effects. Summary statistics, histograms, dot plots, and box plots describe the MOP data. Fisher Least Squares Difference at a 90% confidence level

[254] Naval War College, "Joint Military Operations" course notes, (Naval War College Press, Newport, RI, 2002), pp. 36-37.

identifies primary factor effects. A General Linear Model ANOVA with interaction plots also identifies main factor effects and the following two-factor interactions:

- Sea state and combat level (SS*CL);
- Sea state and Sea Base-to-shore range (SS*R1);
- Sea state and shore-to-objective range (SS*R2);
- Combat level and Sea Base-to-shore range (CL*R1);
- Combat level and shore-to-objective range (CL*R2); and
- Sea Base-to-shore range and shore-to-objective range (R1*R2).

Any factor or interaction with a p-value less than 10% identifies a statistically significant interaction. Hypothesis tests, using pair-wise comparisons of the significant factors or factor interactions, further clarify the significance of the effects. For example, if sea state returns a p-value of 0.087, then sea state is considered to have a significant impact on the performance. A pair-wise t-test between MOPs at sea state 2 and at sea state 3 tests the hypothesis that sea state does not have a significant effect.

10.4.5 Data Management

The data output from the simulation automatically populates a collection of Excel™ spreadsheets. These spreadsheets reduce the data and provide values for each MOE and MOP. Data from these spreadsheets are also imported into MINITAB 14™ for additional analysis. The Meyer Institute at the Naval Postgraduate School retains all of the model output data for archival purposes.

10.5 Modeling Results and Evaluation

The scenario models the 2015 BLA with respect to 9 identified COIs. Table 10-2 shows the complete list of COIs. Enclosure 1 contains the MOE and MOP relationship to their respective COIs. In the modeled scenario, the 2015 BLA meets only 2 of the 9 COIs.

MEASURE	DESCRIPTION
Closure Phase	
COI 1	Can the architecture deliver the Sea Base Maneuver Element (SBME) and the Sea Base Support Element (SBSE) to the Forward Logistics Site (FLS) in time to meet the 10-day requirement?
COI 2	Can the architecture load SBME and the SBSE aboard the Maritime Propositioning Force, Future (MPF(F)) in time to meet the 10-day requirement?
COI 3	Can the MPF(F) get underway in time to meet the 10-day requirement?
COI 4	Can the forces and equipment meet the MPF(F) in transit to the Sea Base location?
Employment phase	
COI 5	Can the architecture employ the SBME to an objective in one period of darkness (10 hrs)?
Seize the Initiative	
COI 6	Can the architecture deliver a JEB to the objective in 10 days?
Sustainment Phase	
COI 7	Can the architecture sustain the JEB from the sea for a minimum of 30 days (720 hrs)?
COI 8	Can the architecture sustain the JEB by vertical lift only?
COI 9	Can the architecture evacuate the wounded troops (MEDEVAC) within the Golden Hour?

Table 10-2: COI Summary.

10.6 Closure Phase

The Closure Phase involves the deployment, transit, assembly of troops and equipment, and the formation of the Sea Base in the Area of Operation (AO).

10.6.1 Deployment and Transit

COI 1 deals with the capability of the 2015 BLA to transport all SBME and SBSE personnel to the FLS for further transfer to the MPF(F) ships. Additionally, the non-prepositioned aircraft must also transit to the FLS and load onto the MPF(F). The MV-22 are self-deploying aircraft that fly to the FLS. The CH-53s, UH-1s, and SH-60s are non-self-deploying aircraft brought to the FLS via strategic airlift. As shown in Figure 10-2, neither the self-deploying nor the non-self-deploying aircraft arrive within sufficient time to load aboard the MPF(F). Not shown in this calculation is the additional time required for the Air Mobility Command (AMC) to plan, coordinate, and establish an air bridge to transport the non-self-deploying aircraft and all non-prepositioned equipment. In addition to the time displayed in Figure 10-2, the air bridge requires another four days to establish.

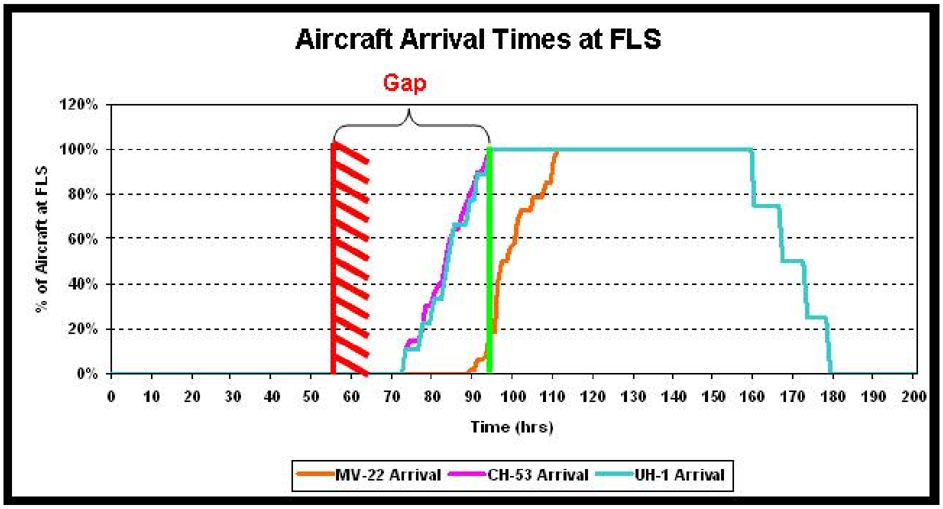


Figure 10-2: Aircraft arrival at FLS. The red line marks the requirement and the green line marks the modeled performance. A capability gap exists.
Note: Add 96 hrs to establish the air bridge.

Figure 10-3 shows that, on average, the arrival of the SBME and SBSE personnel (≈ 8,000) to the FLS falls within the required time of 127 hrs. $T_{CRIT1.1}$ shown in Enclosure 3 describes the criteria for calculating this time requirement.

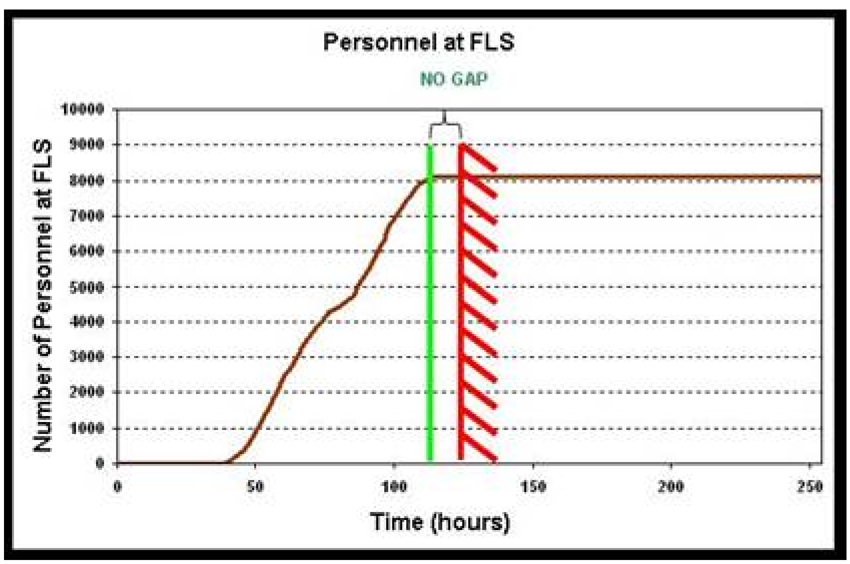


Figure 10-3: Personnel arrival at FLS. No capability gap exists.

10.6.2 Assembly

Each MPF(F) ship is already loaded with the prepositioned equipment, minus aircraft and LCACs. The LCACs are located at the FLS and are craned onboard the

MPF(F) ships while the troops are loading. Helicopters arrive at the FLS as discussed in the previous sections and are flown aboard the MPF(F) ships once maintenance preparations are complete. MV-22 and F-35 aircraft rendezvous with their MPF(F) ship if at sea or at the FLS if their ship is in port.

Upon arrival at the FLS, personnel debark the airlifts and are transported to the pier where two MPF(F) ships are docked. Personnel distribution and load out plans are prearranged so all personnel are located on the same MPF(F) ship as their equipment. Once personnel boarding is complete, each ship transits to the anchorage area to await the arrival of its designated aircraft. After the first MPF(F) ship boards all personnel and clears the pier, the next MPF(F) ship will take its place. This process will continue until all MPF(F) ships are loaded.

COI 2 involves calculating the time the additional equipment arrives to the FLS. The values of $T_{CRIT\ 1.2}$, $T_{CRIT\ 1.3,}$ and $T_{CRIT\ 2.1}$ are shown in detail in Enclosure 3. As seen in Figure 10-4, on average, the non-prepositioned personnel and equipment cannot arrive within the required time.

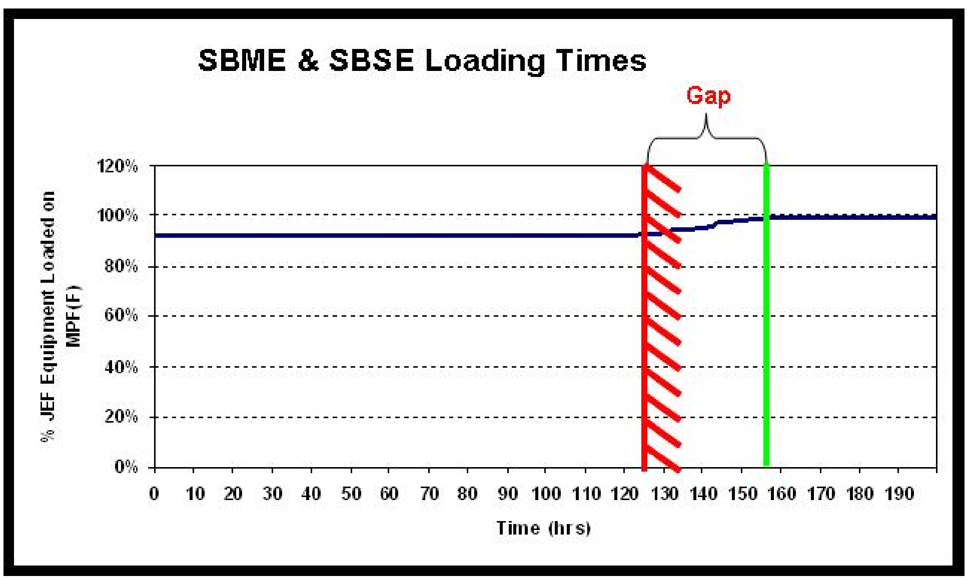


Figure 10-4: Equipment loaded on MPF(F) ships. Capability gap exists for the in port portion of assembly.

10.6.3 Sea Base Formation

COI 3 deals with forming the Sea Base with enough time to employ the three Battalion Landing Teams (BLTs) to the objective within the 10 days required by 10/30/30. In order to arrive at the AO with enough time to employ the BLTs, the MPF(F) must depart 110 hrs from the deployment order. Enclosure 3 shows the calculation performed to arrive at this time critical value. On average, the MPF(F) ships miss the required departure time by 50 hrs, as shown in Figure 10-5. This is mainly due to the delay in aircraft arrival at the FLS.

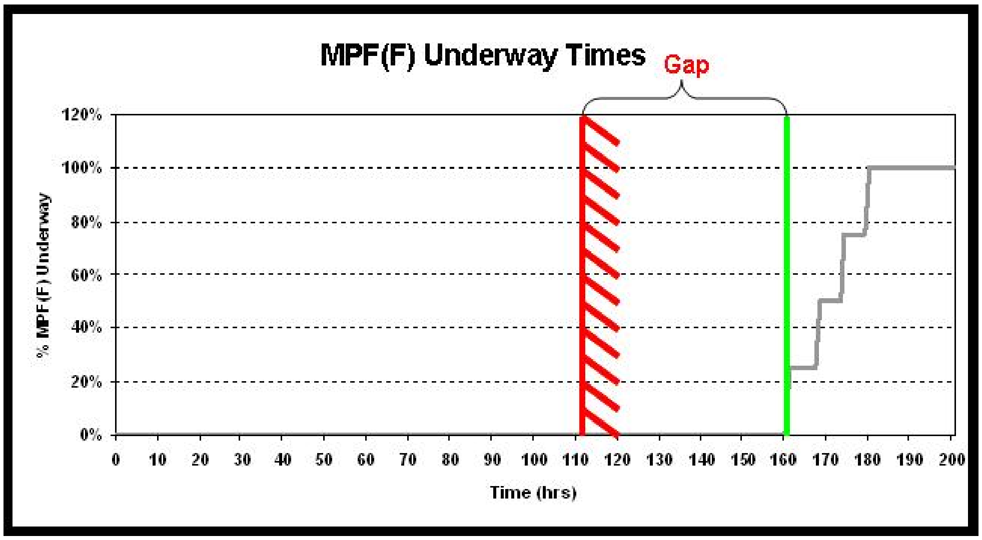


Figure 10-5: MPF(F) Underway Times from FLS. Capability gap exists due to loading effects.

10.7 Employment Phase

The Employment Phase involves delivering the 3 BLTs to the objective within one period of darkness. Air assault connectors deliver 1 BLT, while surface assault connectors deliver the remaining 2 BLTs.

COI 5 involves employing the 3 BLTs that comprise the SBME from the Sea Base to the objective in one period of darkness (10 hrs). Tracking the elapsed time of the employment and calculating the percent of the 3 BLTs that have completely employed yields the resulting performance. Figure 10-6 indicates that, on average, the three BLTs require 30 hrs to complete their employment to the objective. This 20-hr gap

in capability is statistically significant. The delay can be as long as 50 hrs, resulting in a 40-hr gap.

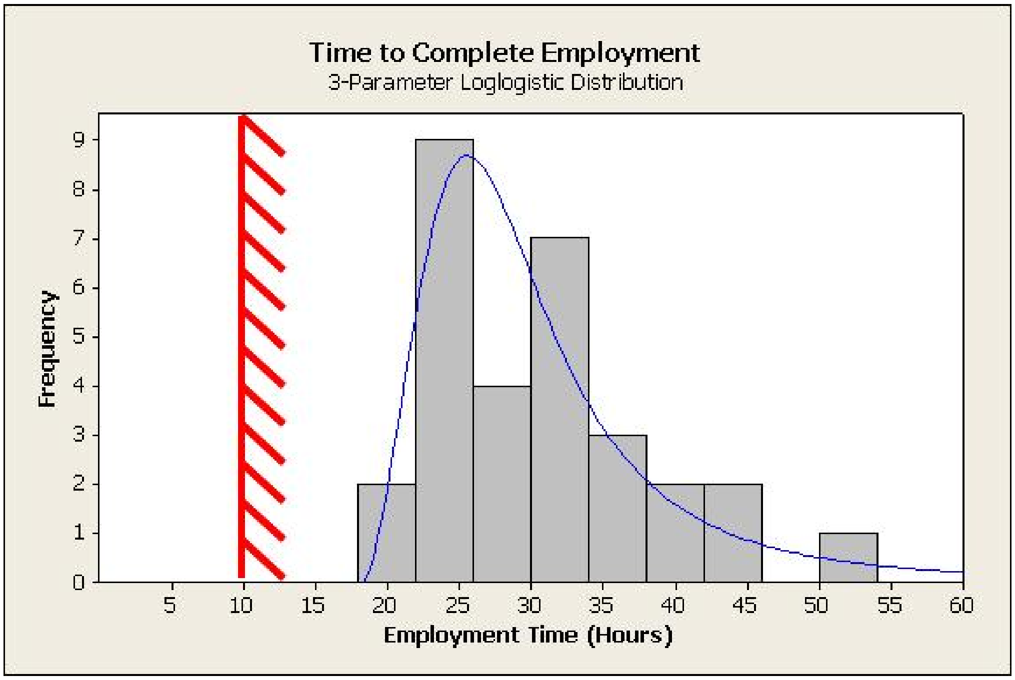


Figure 10-6: SBME Insertion Time to Objective. Capability gap of 20 hrs exists.

10.8 Seize the Initiative

In accordance with the Operating Concept [Chapter 2], the force has 10 days to seize the initiative. In order to seize the initiative, the 2015 BLA must complete the Closure, Assembly, and Employment Phases of operations. COI 6 provides insight into this system requirement.

On average, the 2015 BLA seizes the initiative in 12 + 4 days, or 16 days. The 12-day result is optimistic since it is based on the immediate availability of all assets, including the required strategic airlift assets. The four additional days reflect the time required to establish the air bridge. While this result is a major advantage over today's capability, it still falls short of the desired goal for future combat operations to seize the initiative within 10 days.

10.9 Sustainment Phase

The Sustainment Phase involves delivering supplies from the Sea Base to the objective for a mission time of 30 days. The air assault connectors only sustain the JEB at the objective to avoid having a beach and landlines of communication. Additionally, during the 30-day mission time, a resupply ship from the FLS must also sustain the Sea Base. COI 7 provides the information needed to evaluate this system requirement.

10.9.1 Sea Base Sustainment

The requirement states that the Sea Base must perform sustainment functions for 30 continuous days of operation [Chapter 3]. The amount of supplies stored at the Sea Base (food, water, ammunition, and fuel) is a function of the available storage on the MPF(F) ship. Chapter 5 lists the storage capacity for the MPF(F) ship in the 2015 BLA. The amount of supplies calculated includes pallets of MREs, pallets of bottled water, pallets of ammunition, and gallons of fuel.

As shown in the graphs of Enclosure 4, the Sea Base storage level of these supplies is adequate to sustain the three BLTs at the objective for 30 days. However, the Sea Base does require a resupply of fuel, on average, twice during the 30-day mission time. Extra pallets of food, bottled water, or ammunition may also be brought by the resupply vessel as required.

10.9.2 Objective Sustainment

The air assault connectors of the 2015 BLA must sustain the three BLTs at the objective for 30 days. Both air assault connector quantity and range from Sea Base to the objective factor into these results. From the graphs in Enclosure 4, the 2015 BLA air assault connectors, on average, sustain the objective at the desired level of two days of supply. This shows that the quantity of air assault connectors is adequate for the range specified in the scenario. Additional insight can be gained by determining the maximum range that the three BLTs can be sustained from the Sea Base.

10.9.3 Vertical Sustainment

COI 8 involves determining the maximum vertical sustainment range from the Sea Base. The 2015 BLA identified the CH-53X and the MV-22 as the two air connectors capable of performing vertical sustainment. Figure 10-7 shows that beyond 165 NM, sustainment by the air connectors cannot be achieved. This decline in capability stems from the published maximum external payload endurance of the MV-22.[255] From distances beyond 165 NM, the CH-53X alone cannot sustain the three BLTs.

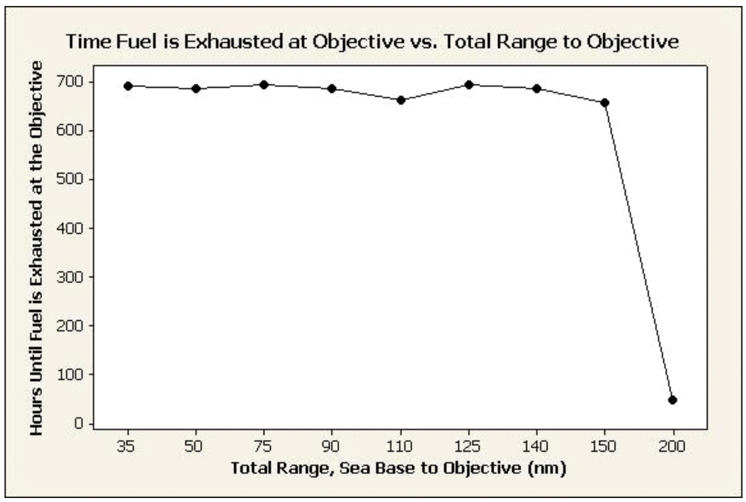


Figure 10-7: Vertical Sustainment Performance. Beyond 165 NM, only the CH-53X can sustain at the objective.

10.9.4 Medical Evacuation

COI 9 deals with the capability to perform medical evacuation of wounded personnel from the objective to the Sea Base within 1 hr [Chapter 2]. The scenario range from Sea Base to objective is 150 NM. As shown in Figure 10-8, on average, the medical evacuation requires 1.3 hrs to complete. The principle reason for this gap revolves around the operational range of the UH-1.

[255] Naval Air Systems Command, NATOPS Flight Manual, Navy Model MV-22B Tiltrotor, Preliminary with Change 3, 01 June 2000.

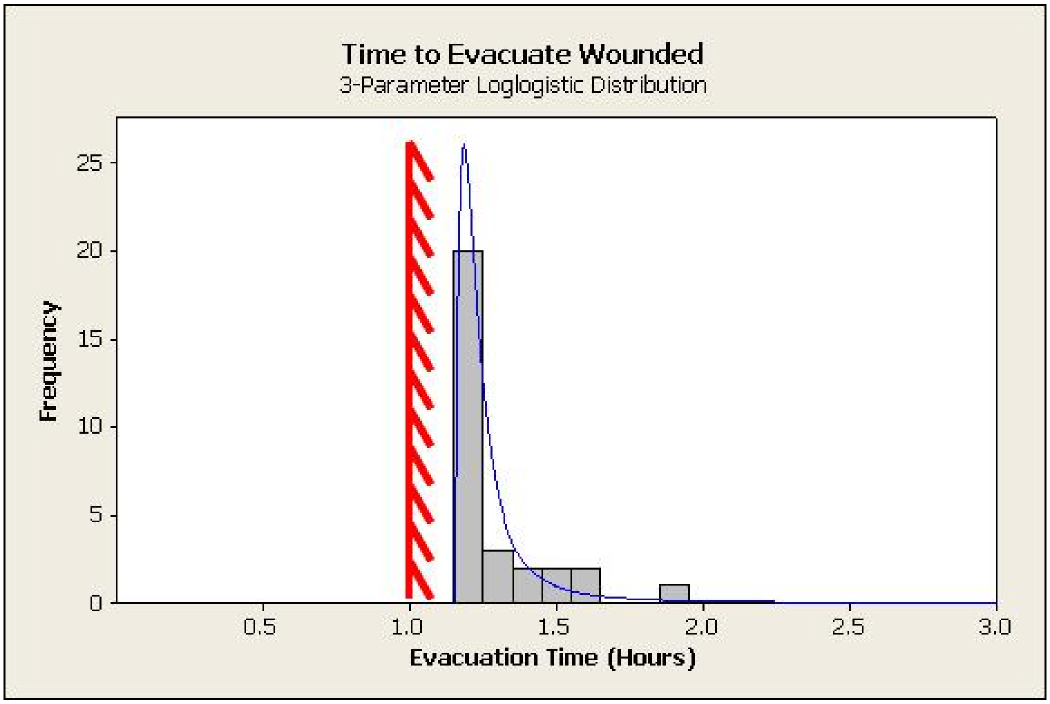


Figure 10-8: Medical Evacuation Times. The operational range of the UH-1 causes this capability gap.

10.10 Summary

Analysis of the SEABASE-6 simulation data indicates that while the 2015 BLA goes a long way toward closing the 2004 capability gaps, it still does not meet the operational goals of 10/30/30 [Chapter 3]. Specifically, it seizes the initiative approximately 6 days past the 10-day requirement. Solutions that transport the non-self-deploying aircraft without the disassembly and reassembly should reduce the closure phase gap. Reducing the time to move the JEB from the Sea Base to the objective or reducing the amount of equipment carried should reduce the employment phase gap. Overall, the 2015 BLA sustains the JEB ashore for 30 days. Evacuation of wounded personnel to the Sea Base takes approximately 20 minutes longer than the 1-hr requirement.

Enclosure 1: Measures

MEASURE	DESCRIPTION
	Closure Phase
COI 1	**Can the architecture deliver the SBME and the SBSE to the FLS in time to meet the 10-day requirement?**
MOE 1.1	The probability that all of the SBME and SBSE troops arrive at the FLS by $T_{CRIT\ 1.1}$.
MOP 1.1.1	Elapsed time until all SBME and SBSE troops arrive at the FLS.
MOP 1.1.2	Percent of SBME and SBSE troops at the FLS at $T_{CRIT\ 1.1}$.
MOE 1.2	The probability that all of the SBME and SBSE equipment[256] arrives at the FLS by $T_{CRIT\ 1.1}$.
MOP 1.2.1	Elapsed time until all SBME and SBSE equipment arrives at the FLS.
MOP 1.2.2	Percent of SBME and SBSE equipment at the FLS by $T_{CRIT1.1}$.
COI 2	**Can the architecture load the SBME and the SBSE aboard the MPF(F) in time to meet the 10-day requirement?**
MOE 2.1	The probability that the SBME and SBSE troops are loaded by $T_{CRIT\ 2.1}$.
MOP 2.1.1	Elapsed time until SBME and SBSE troops are loaded.
MOP 2.1.2	Percent of required personnel loaded by $T_{CRIT\ 2.1}$.
MOE 2.2	Probability that all of the SBME and SBSE equipment[257] is loaded by $T_{CRIT\ 2.1}$.
MOP 2.2.1	Elapsed time until all SBME and SBSE equipment is loaded aboard MPF(F).
MOP 2.2.2	Percent of SBME and SBSE equipment loaded aboard by T_{CRIT}.
COI 3	**Can the MPF(F) get underway in time to meet the 10-day requirement?**
MOE 3.1	The probability of the MPF(F) departing by $T_{CRIT\ 3.1}$.
MOP 3.1.1	Elapsed time at which all MPF(F) are underway.
MOP 3.1.2	Percent of MPF(F) departed by $T_{CRIT\ 3.1}$.
COI 4	**Can the forces and equipment meet the MPF(F) in transit to the Sea Base location?**
MOE 4.1	The probability that the forces and equipment arrive in transit.
MOP 4.1.1	Percent of forces and equipment onboard at a given time. This COI is answered by COI 2. The capability to meet the MPF(F) in transit is reflected in the elapsed time until SBME and SBSE are loaded onto MPF(F).
	Employment Phase
COI 5	**Can the architecture deploy the SBME to an objective in one period of darkness (10 hrs)?**
MOE 5.1	The probability that the SBME can be inserted in one period of darkness (POD) (10 hrs).
MOP 5.1.1	Elapsed time that the SBME is inserted.
MOP 5.1.2	Percent of forces at objective at the completion of one POD.
	Seize the Initiative
COI 6	**Can the architecture deliver a JEB to the Objective in 10 days?**
MOE 0.1	The probability that the JEB is delivered to the Objective within 240 hrs.
MOP 0.1.1	Elapsed time until JEB at the Objective.
MOP 0.1.2	Percent of JEB at the Objective in 240 hrs.
MEASURE	**DESCRIPTION**
	Sustainment Phase
COI 7	**Can the architecture sustain the JEB from the sea for a minimum of 30 days (720 hrs)?**
MOE 7.1	The probability that the JEB personnel at the Sea Base are sustained for 720 hrs (30 days).
MOP 7.1.1	Elapsed time that food is fully depleted at the Sea Base.
MOP 7.1.2	Elapsed time that fuel is fully depleted at the Sea Base.
MOP 7.1.3	Elapsed time that water is fully depleted at the Sea Base.
MOP 7.1.4	Elapsed time that ammunition is fully depleted at the Sea Base.
MOP 7.1.5	Elapsed time that the troops are fully depleted at the Sea Base.
MOP 7.1.6	Percent of time that food falls below the reserve level[258] at Sea Base.

[256] For 2015 Baseline Architecture, this means the nondeployable aircraft.
[257] For 2015 Baseline Architecture, this means the nondeployable aircraft.

MEASURE	DESCRIPTION
MOP 7.1.7	Percent of time that fuel falls below the reserve level at Sea Base.
MOP 7.1.8	Percent of time that water falls below the reserve level at Sea Base.
MOP 7.1.9	Percent of time that ammunition falls below the reserve level at Sea Base.
MOP 7.1.10	Percent of the time that troops fall below the reserve level at the Sea Base.
MOP 7.1.11	Number of times that food falls below the reserve level at Sea Base.
MOP 7.1.12	Number of times that fuel falls below the reserve level at Sea Base.
MOP 7.1.13	Number of times that water falls below the reserve level at Sea Base.
MOP 7.1.14	Number of times that ammunition falls below the reserve level at Sea Base.
MOE 7.2	The probability that the JEB personnel ashore are sustained for 720 hrs (30 days).
MOP 7.2.1	Elapsed time that food is fully depleted ashore.
MOP 7.2.2	Elapsed time that fuel is fully depleted ashore.
MOP 7.2.3	Elapsed time that water is fully depleted ashore.
MOP 7.2.4	Elapsed time that ammunition is fully depleted ashore.
MOP 7.2.5	Elapsed time that the troops are fully depleted ashore.
MOP 7.2.6	Percent of time that food falls below the reserve level ashore.
MOP 7.2.7	Percent of time that fuel falls below the reserve level ashore.
MOP 7.2.8	Percent of time that water falls below the reserve level ashore.
MOP 7.2.9	Percent of time that ammunition falls below the reserve level ashore.
MOP 7.2.10	Percent of time that the troop level falls below the reserve level ashore.
MOP 7.2.11	Number of times that food falls below the reserve level ashore.
MOP 7.2.12	Number of times that fuel falls below the reserve level ashore.
MOP 7.2.13	Number of times that water falls below the reserve level ashore.
MOP 7.2.14	Number of times that ammunition falls below the reserve level ashore.
MOP 7.2.15	Number of times that troop levels fall below the reserve level ashore.
MOE 7.3	Probability that the JEB ashore is not burdened by excessive supplies.
MOP 7.3.1	Percent of time that food quantity ashore is above distribution capacity.
MOP 7.3.2	Percent of time that fuel quantity ashore is above distribution capacity.
MOP 7.3.3	Percent of time that water quantity ashore is above distribution capacity.
MOP 7.3.4	Percent of time that ammunition quantity ashore is above distribution capacity.
MOP 7.3.5	Percent of time that troops quantity ashore is above distribution capacity.
MOP 7.3.6	Number of times that food quantity ashore is above distribution capacity.
MOP 7.3.7	Number of times that fuel quantity ashore is above distribution capacity.
MOP 7.3.8	Number of times that water quantity ashore is above distribution capacity.
MOP 7.3.9	Number of times that ammunition quantity ashore is above distribution capacity.
MOP 7.3.10	Number of times that troops quantity ashore is above distribution capacity.
MOE 7.4	Efficiency of the architecture during the Sustainment Phase.
MOP 7.4.1	Percent of time that food quantity is above the reserve level and below the maximum distribution capacity.
MOP 7.4.2	Percent of time that fuel quantity is above the reserve level and below the maximum distribution capacity.
MOP 7.4.3	Percent of time that water quantity is above the reserve level and below the maximum distribution capacity.
MOP 7.4.4	Percent of time that ammunition quantity is above the reserve level and below the maximum distribution capacity.
MOP 7.4.5	Percent of time that troops quantity is above the reserve level and below the maximum distribution capacity.
COI 8	**Can the architecture sustain the JEB by vertical lift only?**
MOE 8.1	Probability that SBME can be sustained via vertical lift only.
MOP 8.1.1	Percent of required supplies that can be airlifted to designated location.

[258] "Reserve levels" are a matter of policy. As set forth in the FAA [Chapter 3] and the 2015 Baseline Architecture description [Chapter 5], the MPF(F) reserve level is 50% of capacity for each class of supply.

MEASURE	DESCRIPTION
COI 9	**Can the architecture evacuate the wounded troops (MEDEVAC) within the Golden Hour?**
MOE 9.1	Probability that wounded patients are evacuated to the Sea Base within evacuation policy time limit.
MOP 9.1.1	Mean Time to evacuate a wounded soldier from the objective to the Sea Base.
MOP 9.1.2	Percent of wounded evacuated within the evacuation policy time limit.

Enclosure 2: Full Factorial Run Matrix

Run #	Sea State	Level of Combat	Range (SB-Shore)	Range (Shore-OBJ)
1	2	Sustain	25	10
2	2	Sustain	25	50
3	2	Sustain	25	100
4	2	Sustain	40	10
5	2	Sustain	40	50
6	2	Sustain	40	100
7	2	Sustain	100	10
8	2	Sustain	100	50
9	2	Sustain	100	100
10	2	Assault	25	10
11	2	Assault	25	50
12	2	Assault	25	100
13	2	Assault	40	10
14	2	Assault	40	50
15	2	Assault	40	100
16	2	Assault	100	10
17	2	Assault	100	50
18	2	Assault	100	100
19	3	Sustain	25	10
20	3	Sustain	25	50
21	3	Sustain	25	100
22	3	Sustain	40	10
23	3	Sustain	40	50
24	3	Sustain	40	100
25	3	Sustain	100	10
26	3	Sustain	100	50
27	3	Sustain	100	100
28	3	Assault	25	10
29	3	Assault	25	50
30	3	Assault	25	100
31	3	Assault	40	10
32	3	Assault	40	50
33	3	Assault	40	100
34	3	Assault	100	10
35	3	Assault	100	50
36	3	Assault	100	100
37	4	Sustain	25	10
38	4	Sustain	25	50
39	4	Sustain	25	100
40	4	Sustain	40	10
41	4	Sustain	40	50
42	4	Sustain	40	100
43	4	Sustain	100	10
44	4	Sustain	100	50
45	4	Sustain	100	100
46	4	Assault	25	10
47	4	Assault	25	50
48	4	Assault	25	100
49	4	Assault	40	10
50	4	Assault	40	50

Run #	Sea State	Level of Combat	Range (SB-Shore)	Range (Shore-OBJ)
51	4	Assault	40	100
52	4	Assault	100	10
53	4	Assault	100	50
54	4	Assault	100	100

Enclosure 3: Timeline Analysis for 2015 Baseline Architecture

From Chapter 3, the requirement is to have three BLTs at the objective in 10 days (240 hrs). The 240 hrs breaks down as follows:

240 hrs = $T_{CONUS\_FLS} + T_{XIT} + T_{UW} + T_{LOAD} + T_{DEPLOY}$.

T_{CONUS_FLS} = Time (hours) for the troops and nondeployable aircraft to transit from the Continental United States (CONUS) to the FLS.

T_{XIT} = Time (hours) to transit from the FLS to the Sea Base = distance/speed, where distance is from the FLS to the Sea Base and speed is an input variable of the FLS-to-Sea Base connector (MPF(F)).

T_{UW} = Time (hours) for MPF(F) to get underway (input based on outside analysis).

T_{LOAD} = Time (hours) for MPF(F) to load (input based on outside analysis).

T_{DEPLOY} = Time (hours) for the three BLTs of the SBME to get from the Sea Base to the objective.

Burma Scenario Values

Distance FLS to Sea Base is an input from the scenario = 2,000 NM

MPF(F) speed = 20 kts

$T_{CRIT\ 1.1}$

$T_{CRIT\ 1.1}$ is the latest time that the JEB can arrive at the FLS and still make it to the objective by hour 240 (day 10). T_{CRIT} depends on the scenario for distance to travel and the architecture for speed of advance of connector.

$T_{CRIT\ 1.1}$ = 240 hrs – T_{XIT} – T_{UW} –T_{LOAD} - T_{DEPLOY}

T_{XIT} = (2,000 NM)/(20 kts) = 100 hrs

T_{UW} = 3 hrs T_{LOAD} = included in T_{UW} T_{DEPLOY} = 10 hrs

$T_{CRIT\ 1.1} = 240 - 100 - 3 - 10 = \boxed{127\ \text{hrs}}$

$T_{CRIT\ 1.2}$

$T_{CRIT\ 1.2}$ is the latest time that the non-self deploying aircraft can arrive at the FLS and still make it to the objective by hour 240 (day 10). It is calculated in the same manner as $T_{CRIT\ 1.1}$.

$T_{CRIT\ 1.2} = 230\ \text{hrs} - T_{XIT} - (T_{UW} + T_{LOAD})$

$T_{XIT} = 100$ hrs $T_{UW} = 3$ hrs $T_{LOAD} = E(\text{uniform } 60;84) = 72$ hrs

$T_{CRIT\ 1.2} = \boxed{55\ \text{hrs}}$

$T_{CRIT\ 1.3}$

$T_{CRIT\ 1.3}$ is the latest time that the non-self-deploying aircraft can arrive at the FLS and still make it to the objective by hour 240 (day 10). It is calculated in the same manner as $T_{CRIT\ 1.1}$.

$T_{CRIT\ 1.3} = 230\ \text{hrs} - T_{UW} - T_{XIT}$

$T_{XIT} = 65$ hrs $T_{UW} = E(\text{uniform } 24;48) = 36$ hrs

$T_{CRIT\ 1.2} = \boxed{129\ \text{hrs}}$

$T_{CRIT\ 2.1}$

$T_{CRIT\ 2.1}$ is the latest time the force can be loaded aboard and still make it to the objective by hour 240 (day 10). It is a calculated in the same way as $T_{CRIT\ 1.1}$.

$T_{CRIT\ 2.1} = 240\ \text{hrs} - T_{XIT} - T_{UW} - T_{DEPLOY}$

T_{XIT}, T_{UW}, AND T_{DEPLOY} are the same as above.

$T_{CRIT\ 2.1} = \boxed{127\ \text{hrs}}$

$T_{crit\ 3.1}$

$T_{CRIT\ 3.1}$ is the latest time the last MPF(F)can get underway and still make it to the objective by hour 240 (day 10). It is a calculated in the same way as $T_{CRIT\ 2.1}$.

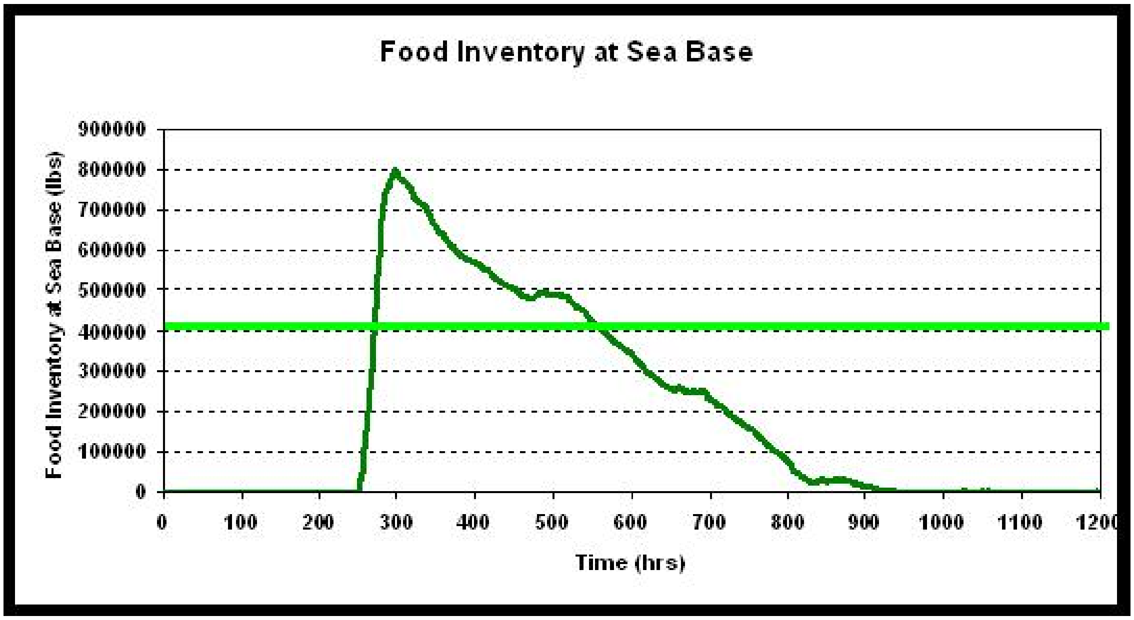
$T_{CRIT\ 3.1} = 240\text{ hrs} – T_{XIT} - T_{DEPLOY}$ where….

T_{XIT} and T_{DEPLOY} are the same as for MOE 1.1 above

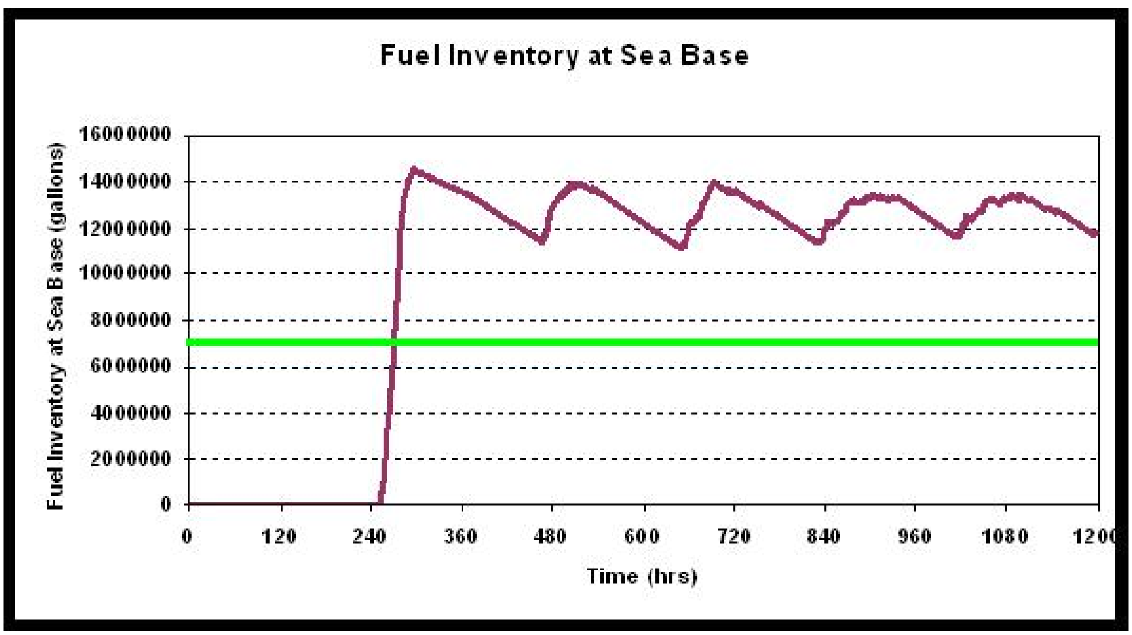
$T_{CRIT\ 3.1} = 240 – 100 – 10 = \boxed{130\text{ hrs}}$

Enclosure 4: Supporting Data

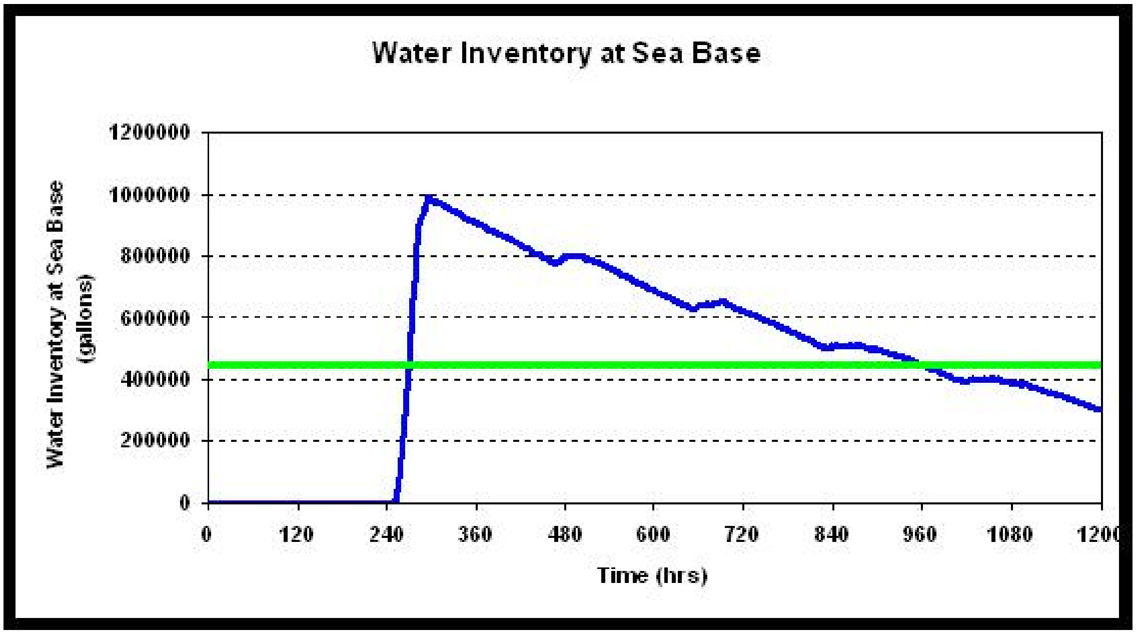
Sea Base Inventory Levels



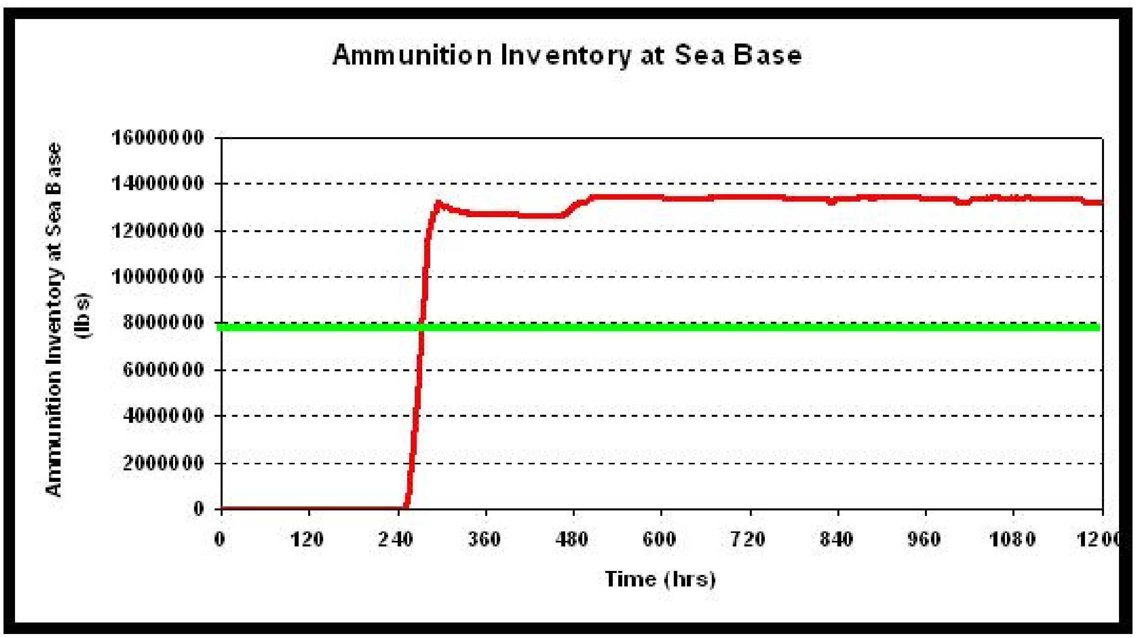
2015 BLA Food Inventory at the Sea Base (Burma Scenario). The green line represents the reserve level onboard the MPF(F).



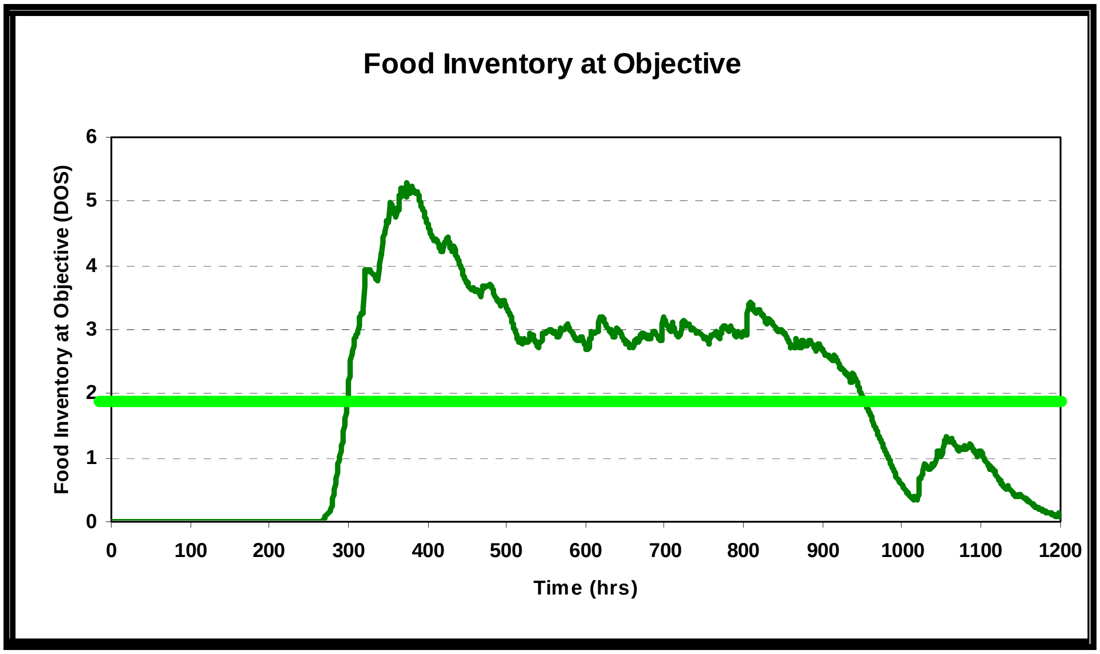
2015 BLA Fuel Inventory at the Sea Base (Burma Scenario). The green line represents the reserve level onboard the MPF(F).



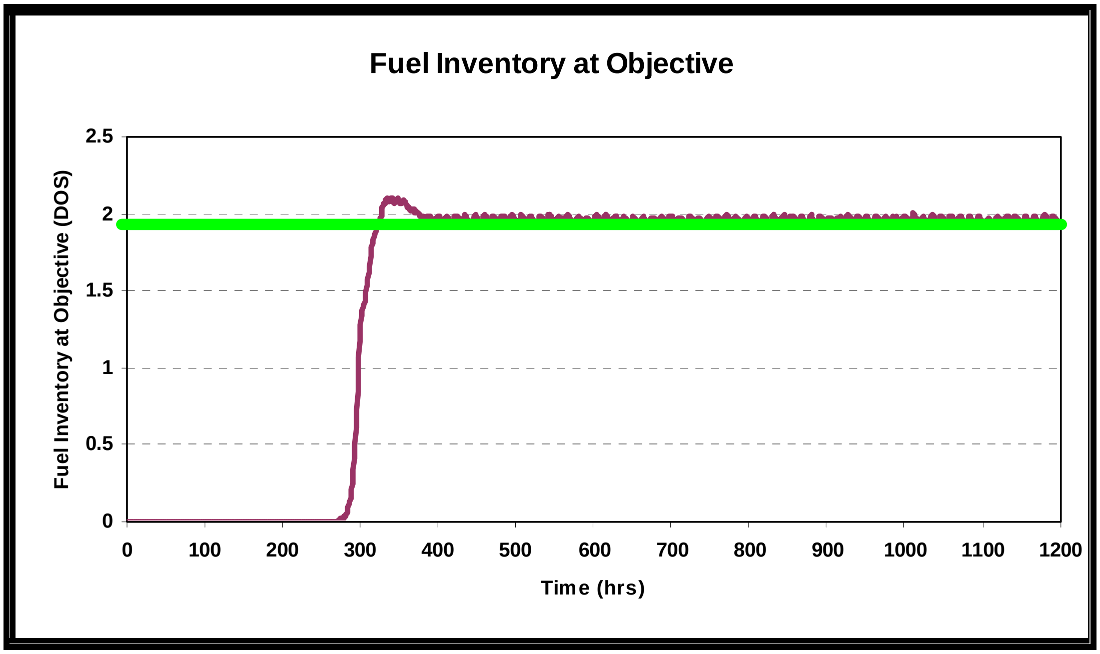
2015 BLA Water Inventory at the Sea Base (Burma Scenario). The green line represents the reserve level onboard the MPF(F).



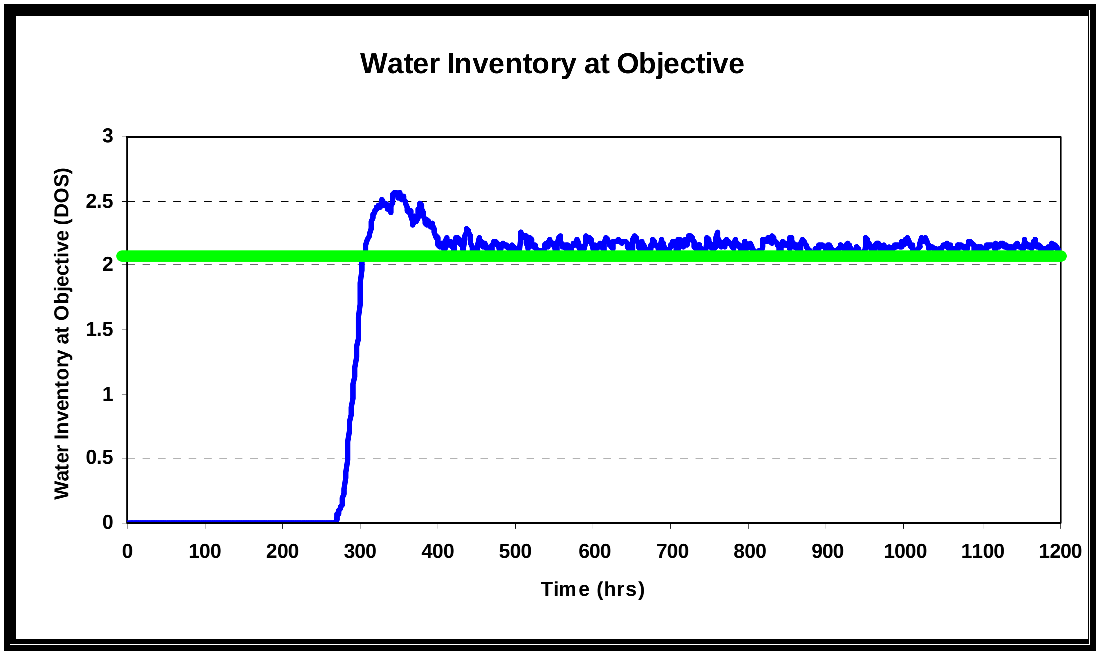
2015 BLA Ammunition Inventory at the Sea Base (Burma Scenario). The green line represents the reserve Level onboard the MPF(F).



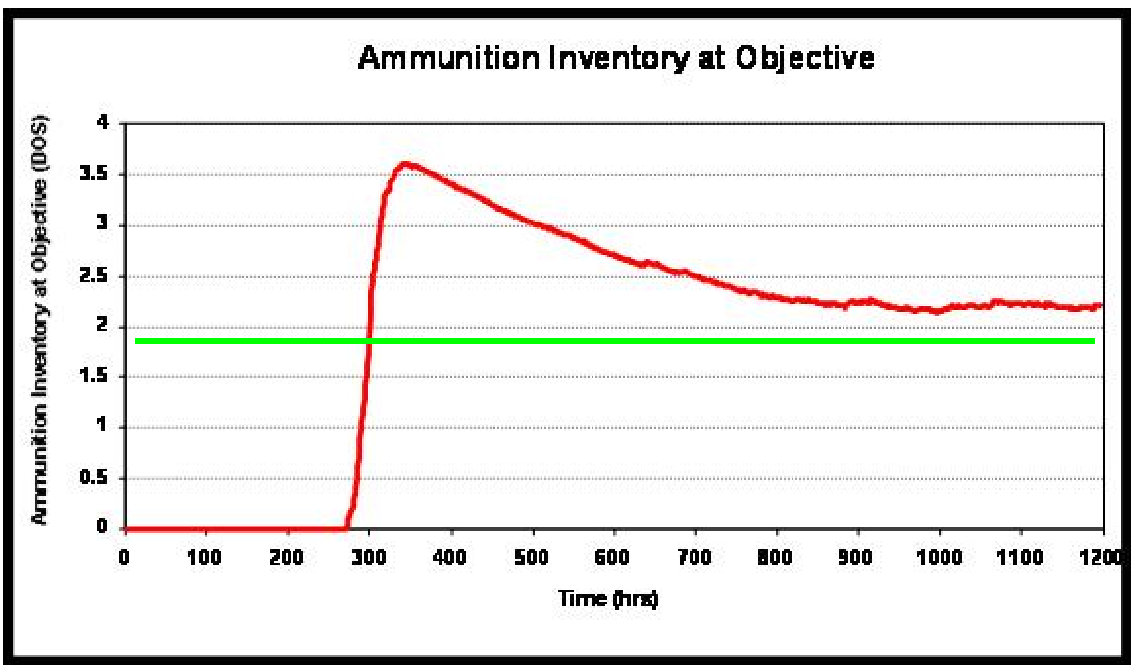
2015 BLA Food Inventory at the Objective (Burma Scenario). The green line represents the reserve level onboard the MPF(F).



2015 BLA Fuel Inventory at the Objective (Burma Scenario). The green line represents the reserve level onboard the MPF(F).



2015 BLA Water Inventory at the Objective (Burma Scenario). The green line represents the reserve level onboard the MPF(F).



2015 BLA Ammunition Inventory at the Objective (Burma Scenario). The green line represents the reserve level onboard the MPF(F).

11. Sensitivity Analysis

11.1 Overview

A sensitivity analysis is performed to determine how much impact a specific parameter or group of parameters has on overall model performance. The sensitivity analysis of the SEABASE-6 simulation model aids in the Functional Solutions Analysis (FSA) phase by providing focused insight into the complex Seabasing and Joint Expeditionary Logistics (JELo) system to identify system behaviors, interactions, performance drivers, and coupling effects within the system. Its results, when combined with the system capability gaps identified in the Functional Needs Analysis (FNA), enable alternative solution design teams to focus efficiently toward high-impact **d**octrine, **o**rganization, **t**raining, **m**ateriel, **l**eadership and education, **p**ersonnel and **f**acilities (DOTMLPF) changes.

SEABASE-6 model's sensitivity analysis is conducted using the 2015 Baseline Architecture (2015 BLA). Unless otherwise specified, the architecture parameter values listed in Appendix B are germane for each of the sensitivity analysis simulations described in this chapter. Variables that are key design drivers within the Seabasing System's four functional areas (connectors, transfers, inventory and storage, command and control) are varied across a range of operationally significant values to determine their impact on overall system performance as defined by Measures of Effectiveness (MOEs) and Measures of Performance (MOPs). With the exception of the variable under evaluation, all other parameters in the model are frozen to their baseline values as defined in Appendix B. The springtime Andaman Sea module (Burma Scenario) is the sea state module used for all simulations. A 30-trial Monte Carlo simulation for each parameter value under test produces raw data model outputs in Microsoft™ Excel format. Calculations are then conducted on the raw data in Excel spreadsheets and then fed into the MINITAB 14 statistical software package for more detailed analytical review.

11.2 Parameters Analyzed

Sensitivity analysis is conducted on the key Seabasing and JELo architecture parameters listed in Table 11-1. Also listed in Table 11-1 are the associated values for which each parameter is varied. Both Employment and Sustainment tasks are examined.

	Sensitivity Analysis Parameter	Specific Parameter Values
Employment Phase	Quantity of operational at-sea surface assault vehicle (i.e., LCAC) loading platforms for the MPF(F) element of the Sea Base.	1, 2, and 3 interfaces per MPF(F) vessel
	Mean Time Between Failure for the surface assault connector.	20, 30, 40, and 50 hrs
	Connector load time associated with the at-sea transfer of equipment between the MPF(F) vessel and the surface assault connector (i.e., LCAC).	0.5, 1.0, 1.5, and 2.0 hrs
	On-deck connector load time of an air connector	12, 18, 24, and 30 minutes
	Time to complete a specified number of surface assault connector trips between the Sea Base and the shore objective.	25, 50, 75, and 100 trips
	Speed of surface assault connector.	25, 35, 45, and 55 kts
Sustainment Phase	Quantity of CH-53 equivalent aircraft to sustain operations ashore from the Sea Base at a distance of 200 NM.	20, 30, 40, and 50 aircraft
	Quantity of dedicated logistics vertical replenishment deck spots for the MPF(F) element of the Sea Base.	2, 4, 6, and 8 deck spots for the Sea Base per MPF(F) squadron

Table 11-1: List of Variables and Associated Values for Sensitivity Analysis.

11.3 Measures of Performance

Employment times measure performance for sensitivity study parameters affecting the Employment phase. Employment time is the time required to employ two surface battalion landing teams (BLT) and one vertical BLT from the Sea Base to the shore objective. The operational requirement is to complete the employment in less than 10 hrs (one period of darkness).

The measure of performance for sensitivity study parameters affecting the Sustainment Phase is on-hand fuel inventory at the objective, measured in days-of-supply (DOS). The goal is to maintain the fuel on-hand inventory at the reorder point of 2 DOS to provide an acceptable safety stock. If fuel drops below the critical level of

1 DOS, sustainment fails. Fuel is the commodity tracked for performance analysis as it comprises over 50% of the daily lift requirements by weight.

11.4 Results

The following sections describe each individual sensitivity test in more detail. The assumptions, external factor settings, as well as any specific parameter changes to frozen baseline variable values are discussed. Graphs and statistical analysis of the sensitivity data are also presented. Finally, key insights into the performance of the Seabasing and JELo system are presented based on data analysis. Figure 11-1 shows a generic box plot with definitions for the symbology.

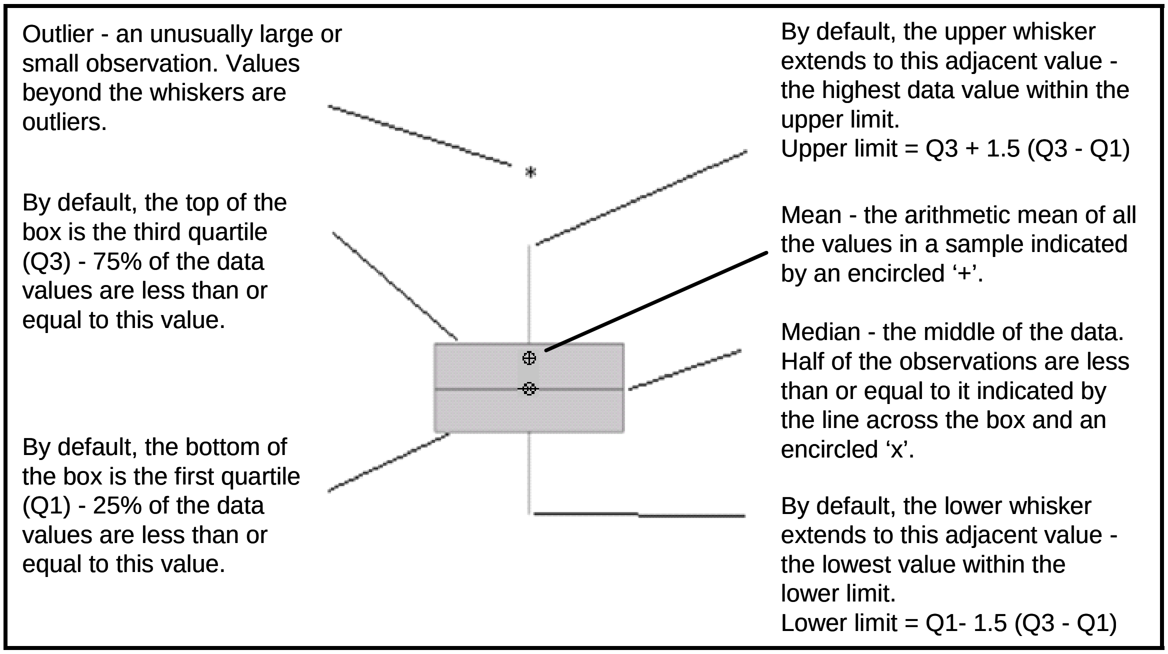


Figure 11-1: Generic Box Plot Showing Standard Symbology.

11.5 Surface Interfaces

Varying the quantity of surface interfaces on each MPF(F) ship determines if multiple surface interface points enhance overall system performance during the Employment Phase. The quantity of interfaces per MPF(F) ship varies from 1 to 3 interfaces in single increments. The distance from the Sea Base to the beach objective during the employment phase is 25 NM.

11.5.1 Data

The box plot of employment time as a function of surface craft loading interface quantity is depicted in Figure 11-2. A pairwise comparison between a single interface configuration and a dual interface configuration is depicted in Figure 11-3 to show the statistically significant difference.

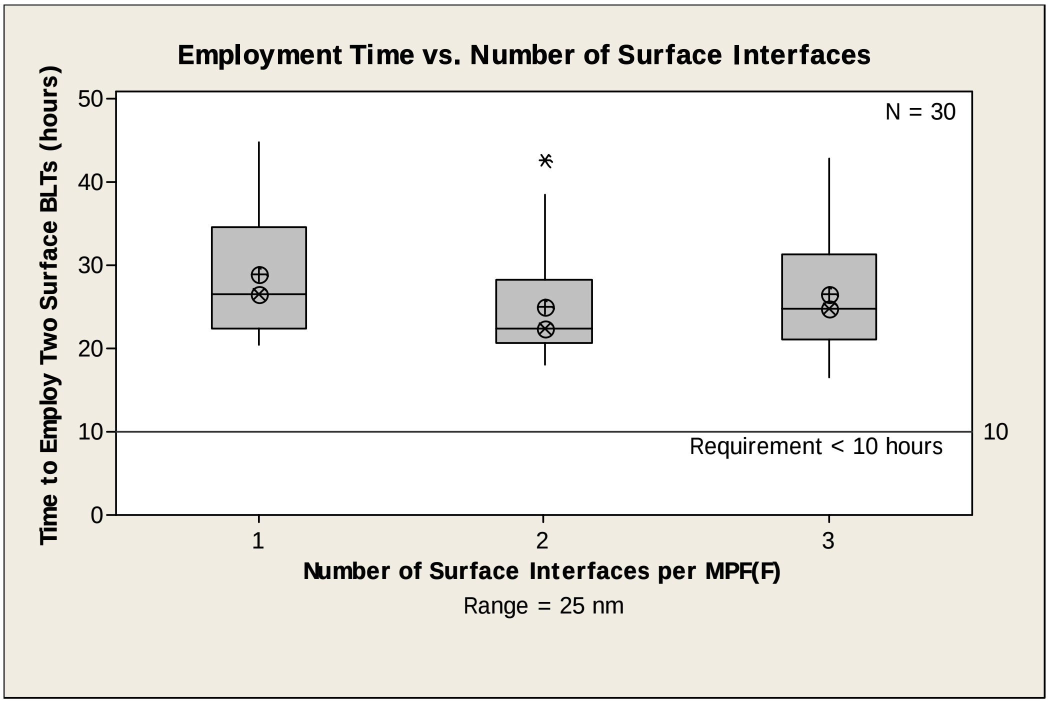


Figure 11-2: Box Plot of Employment Time as a Function of Surface Interface Quantity.

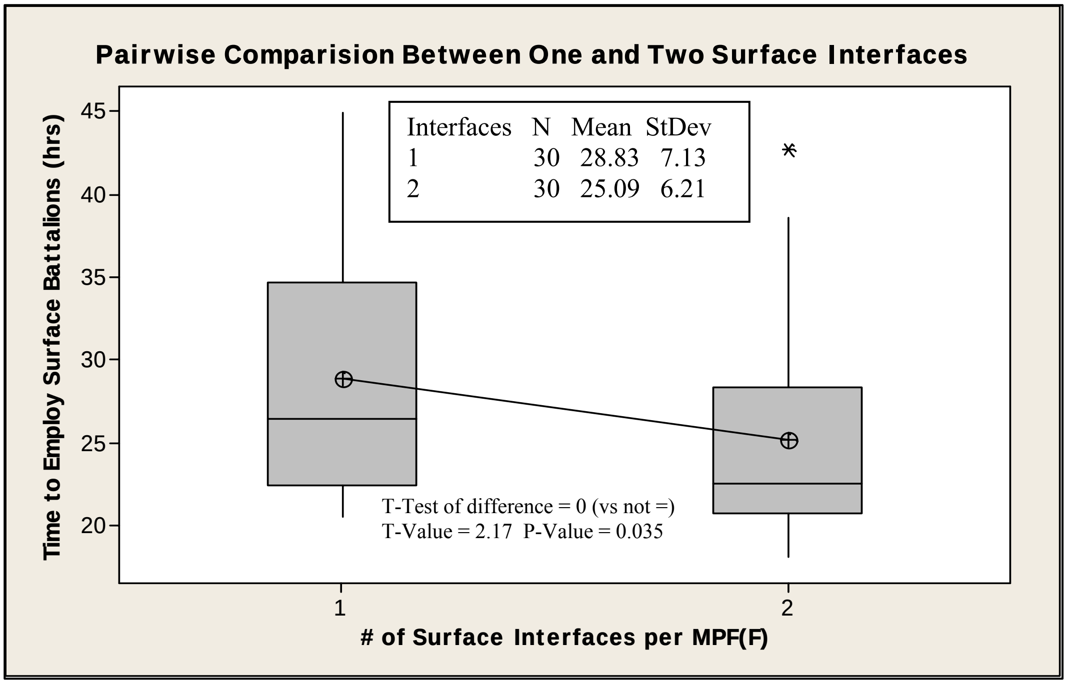


Figure 11-3: Pairwise Comparison Between One and Two Surface Interfaces per MPF(F) Ship.

11.5.2 Insights

The data suggests that additional surface interfaces produce minimal performance gains during the Employment Phase. A statistically significant system performance gain of approximately 3 hrs is evident for the Employment Phase utilizing two surface interfaces vice a single interface. Adding more than two interfaces provides no further benefit in system performance.

Analysis suggests that the 3-hr performance gain for the two-interface configuration is primarily a result of two effects. Approximately 1 to 2 hrs of the 3-hr performance gain can be attributed to loading the first wave of assault vehicles simultaneously. The remainder of the performance gain is attributed to the elimination of queuing delays at the Sea Base during assault connector reloading. The average queuing delay at the Sea Base when utilizing a single interface is approximately 1 minute, with a maximum waiting time of 2 1/2 minutes. The two-interface configuration eliminates the queuing delay at the Sea Base.

The low rate of utilization is a possible reason for the minimal performance gain in multiple platform configurations. Analysis suggests that the low reliability of the LCAC in the 2015 BLA may be a confounding variable. A future sensitivity analysis on multiple surface interface configurations incorporating a more reliable surface connector is recommended.

11.6 Dedicated Logistics Aircraft Deck Spots

Varying the quantity of available operational aircraft deck spots dedicated to logistics at the Sea Base determines the minimum quantity needed to conduct sustainment operations. Fuel inventory at the objective, maintained at 2 DOS, is the MOE. The quantity of aircraft deck spots dedicated to logistics is varied between 2 and 8, in multiples of 2. In this sensitivity study, the quantity of deck spots is associated with the Sea Base vice individual ships so that the data is extensible to any MPF(F) ship architectural combination. The distance from the Sea Base to the objective is 150 NM.

11.6.1 Data

Figure 11-4 depicts Seabasing and JELo system sustainment performance as a function of dedicated logistics operational Sea Base aircraft deck spots.

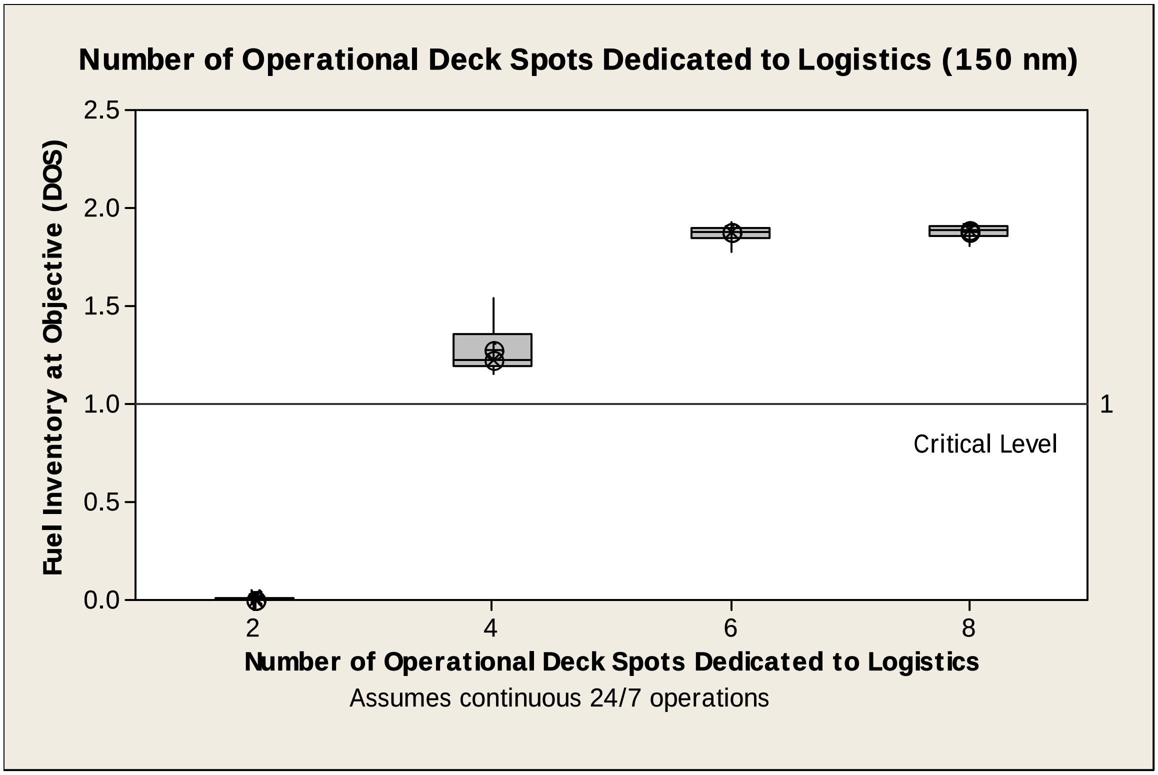


Figure 11-4: Box Plot of Operational Deck Spots Dedicated to Logistics to Sustain a JEB Force Ashore from a Distance of 150 NM.

11.6.2 Insights

The data suggests that a minimum of 6 dedicated logistics aircraft deck spots are required to be in operation over a 24-hr period in order to sustain the objective from a range of 150 NM. There is no performance gain if the number of deck spots is increased from 6 to 8. Four dedicated logistics deck spots is enough to maintain the objective inventory above the critical level, but with an unacceptable safety stock of less than one-third DOS. A dedicated logistics deck spot is, by definition, one that is only used for logistics purposes to support forces ashore. It is operational 24-hrs a day, seven days a week. Any competing resources for aircraft deck spots such as nonlogistics missions or nonlogistics aircraft (i.e., Joint Strike Fighter, AH-1 Cobra, etc.) increase the required number of operational deck spots for the Sea Base.

11.7 Mean Time between Failure of the Surface Assault Connector

Varying the surface assault connector mean-time-between-failure (MTBF) determines its impact on system performance during the Employment Phase. Surface assault connector MTBF times are varied between operationally significant values of 20 to 50 hrs in 10-hr increments. These values equate to approximate operational availabilities of 52%, 62%, 68%, and 73% based on assumed Mean Time To Repair (MTTR) of 16 hrs and logistics delays of 2 1/2 hrs. The distance between the Sea Base and the beach objective during the Employment Phase is 25 NM.

11.7.1 Data

Figure 11-5 depicts the box plot of employment time as a function of surface assault vehicle MTBF. Figure 11-6 illustrates the statistically significant difference between an MTBF of 20 hrs and 30 hrs.

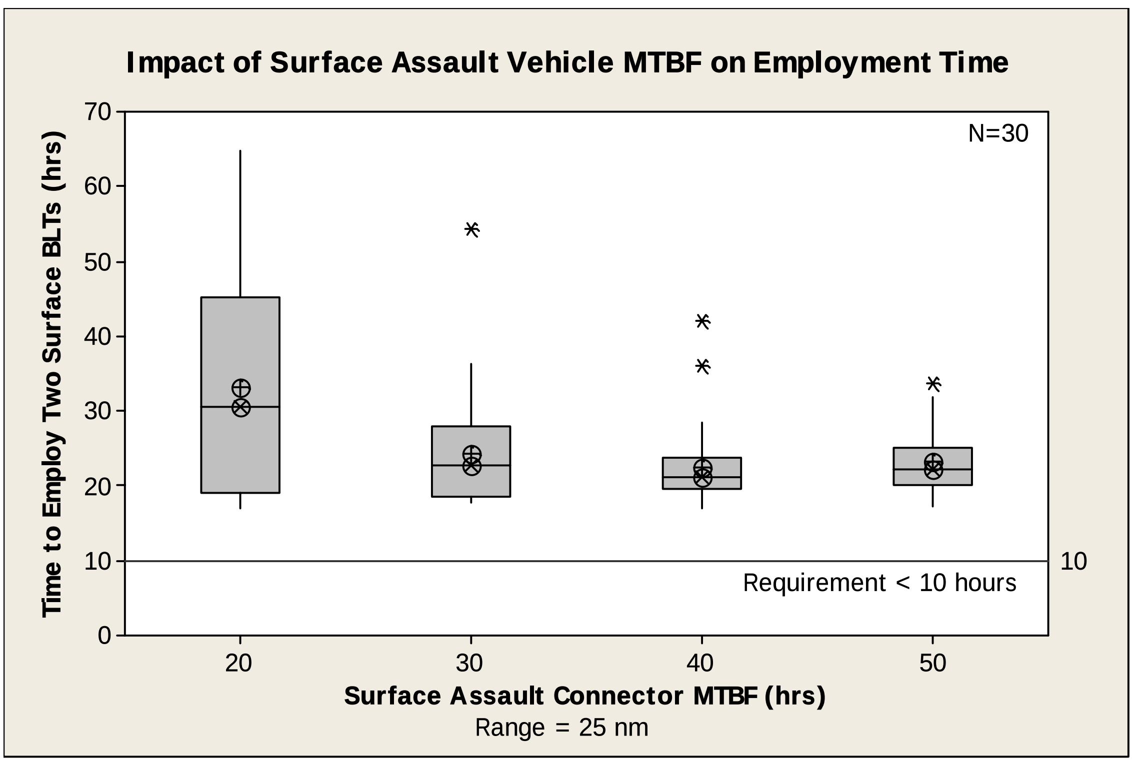


Figure 11-5: Box Plot of Employment Time as a Function of Assault Vehicle MTBF.

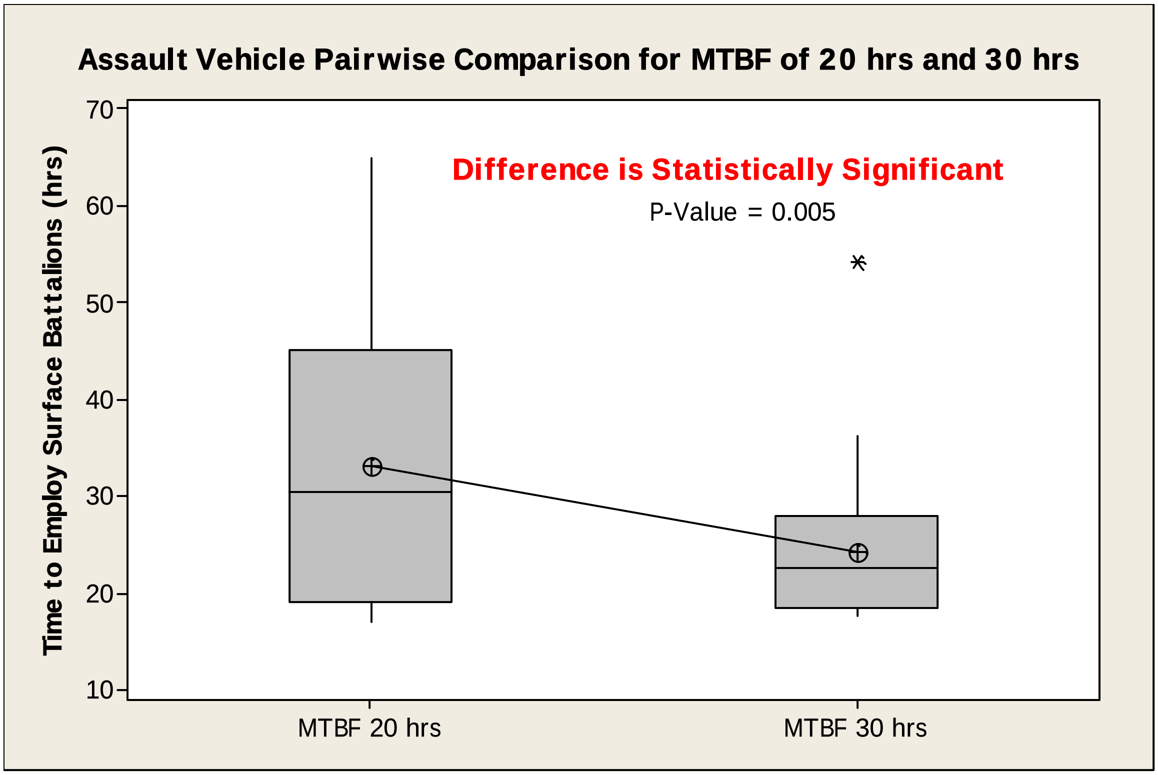


Figure 11-6: Pairwise Comparison Between an MTBF of 20 Hrs and 30 Hrs.

11.7.2 Insights

The data suggests that MTBF is a primary performance driver during the Employment Phase. Problems arise when the MTBF is equal to or less than the time necessary to complete the Employment Phase. A statistically significant performance gain is evident when increasing the MTBF from 20 hrs to 30 hrs. This 10-hr MTBF increase equates to a roughly 9-hr reduction in employment time, yielding a 27% performance gain. The data also suggests that as long as the MTBF of the surface assault connector is greater than the elapsed time necessary to employ forces, it will not have a statistical impact on performance.

During the simulation runs when MTBF is set at 20 hrs, maintenance queue length for average surface assault connector awaiting maintenance is 1.06 +/– 0.06 with an average waiting time of 15.5 +/– 0.5 hrs. This is significant since, on average, of the 3 surface assault connectors assigned to each MPF(F) ship, 1 is operational, 1 is being repaired, and 1 is awaiting maintenance. By contrast, during the 30-hr MTBF simulation,

the average queue length for awaiting maintenance is reduced to 0.54 +/– 0.15 and the average maintenance waiting time is reduced to 10.3 +/– 2.8 hrs. The data suggests that significant performance gains may be achieved through a 50% improvement in reliability.

The data also suggests that MTBF is a key contributor to variance within the system. This variance is most pronounced when the MTBF value is equal to or less than mission duration. An increase in variance makes it difficult to predict system performance. As MTBF values are increased to levels greater than the mission duration, variance in system performance is dramatically reduced.

11.8 Surface Assault Connector Loading Time

Varying the loading time of the surface assault connector at the Sea Base determines if the loading time is a primary system driver during the Employment Phase. Loading times are varied in 30-minute increments between 30 minutes and 2 hrs. During this sensitivity test, transfer times are input to the model as constants that do not fluctuate with sea state so that the overall effect of the transfer delay is not confounded by sea state. It is assumed that increasing sea state will increase the time needed to load a surface assault connector The distance between the Sea Base and the beach objective during the Employment Phase is 25 NM.

11.8.1 Data

Figure 11-7 depicts the box plot for surface battalion employment time as a function of the surface assault connector at-sea loading time at the Sea Base.

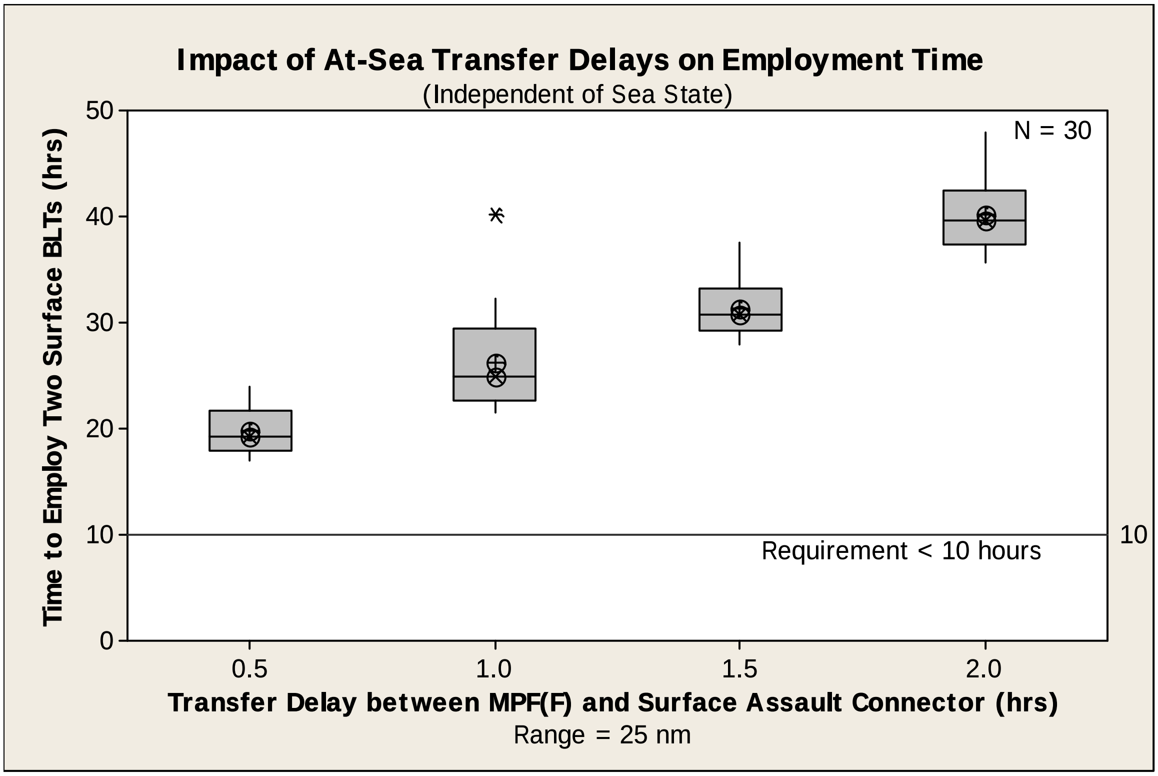


Figure 11-7: Employment Time as a Function of Surface Assault Connector Transfer/Loading Delay at the Sea Base.

11.8.2 Insights

Reduction of the transfer time at the Sea Base is essential. The data suggests that the loading time for the surface assault connector at the Sea Base is a primary system performance driver. It is important to note that even with a very short loading time of 30 minutes (very difficult to achieve in reality with current or planned systems), the employment time is 20 hrs, twice the 10-hr operational requirement. Therefore, minimizing the loading time by itself will not close the Employment Phase capability gap. Consideration should be given to eliminating transfer operations if possible.

Increasing the loading time 30 minutes has an almost linear effect on system performance for delays between 30 minutes and 1 1/2 hrs. For each 30-minute delay increment, the employment time increases by approximately 5 hrs. However, the performance decrement between the 1 1/2-hr and the 2-hr delay is significantly greater, with an increase in employment time of 9 hrs (31 hrs to 40 hrs). At first glance, the

larger performance decrement is due to queuing delays, however, even with a 2-hr loading time, surface assault connector queuing delays at the Sea Base are negligible. The root cause of the larger performance decrement at 2 hrs appears to be an interaction effect with the surface assault connector MTBF and overall surface assault connector availability.

11.9 Air Connector Loading Time

Varying the loading time between the MPF(F) and the air connector determines the impact it has on overall system performance during the Sustainment Phase. This sensitivity study combines into a single delay, the multiple individual delays within the model. This single delay represents the summation of commodity strike-up, staging, loading, and aircraft refueling times while an aircraft occupies an operational deck spot. For this analysis, the distance from the Sea Base to the objective during the Sustainment Phase is 150 NM.

11.9.1 Data

Figure 11-8 depicts vertical sustainment capability from the Sea Base as a function of the loading time for air connector operations from MPF(F) ships.

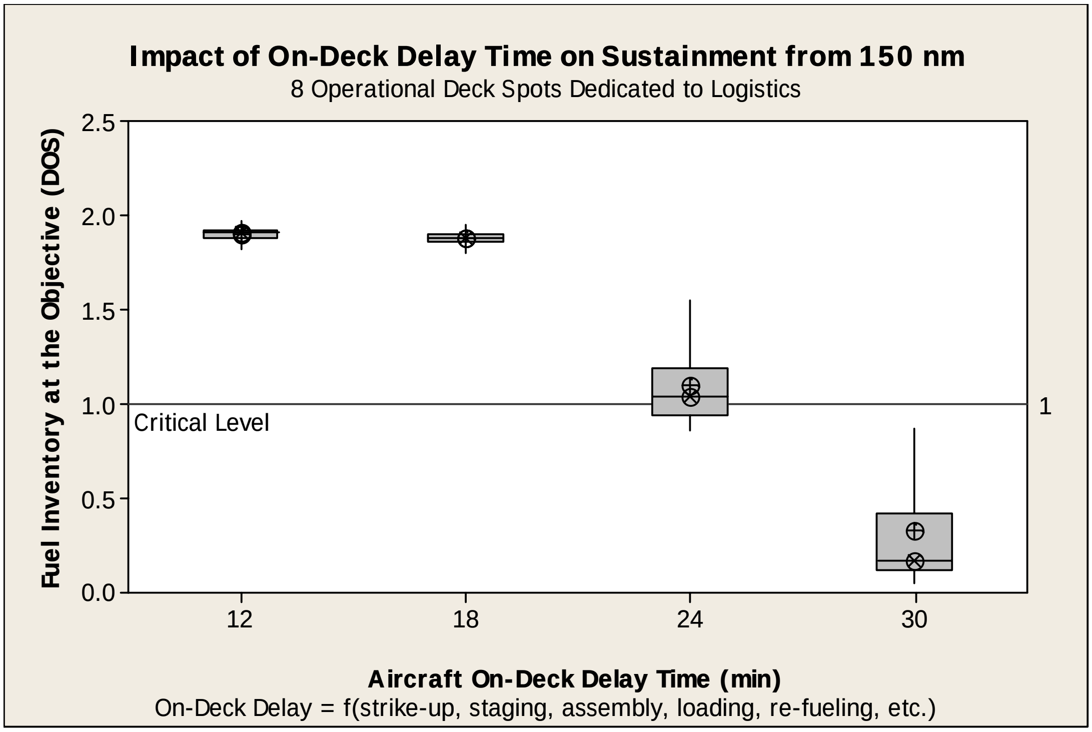


Figure 11-8: Impact of On-Deck Delay Time on Sustainment Operations from the Sea Base at 150 NM.

11.9.2 Insight

The data suggests that there is a significant difference in system performance with transfer times between 18 and 30 minutes. Transfer times of less than 18 minutes are sufficient to sustain the objective with an adequate amount of fuel. System performance declines as transfer time increases above 18 minutes. A transfer time of 24 minutes only allows fuel sustainment at the objective to be maintained at the critical level. Transfer times greater than 24 minutes provide insufficient sustainment.

At long ranges, such as the 300 NM round-trip evaluated, this 18-minute on-deck loading time would include the time permitted to hot-pump refuel the air connectors. In addition, it drives the response time of the inventory and storage system to ensure that ordered commodities are ready for transfer to the air connector within 18 minutes.

11.10 Surface Assault Connector Trips

Varying the number of surface assault connector trips between the MPF(F) and the beach objective highlights how the number of trips affect the time required to employ 2 surface BLTs. The 2015 BLA required 127 surface connector trips to employ the 2 surface BLTs. Surface assault connector trips are varied between 25 and 100, in increments of 25 trips. Employment range is 25 NM and the total number of surface assault connectors at the Sea Base is 24, with 8 operational surface interface spots. The MTBF for the surface assault connector is 26 hrs and drawn from an exponential distribution yielding an approximate operational availability of 58%.

11.10.1 Data

Figure 11-9 depicts the impact of surface assault connector trips on the time to employ 2 surface BLTs ashore from the Sea Base.

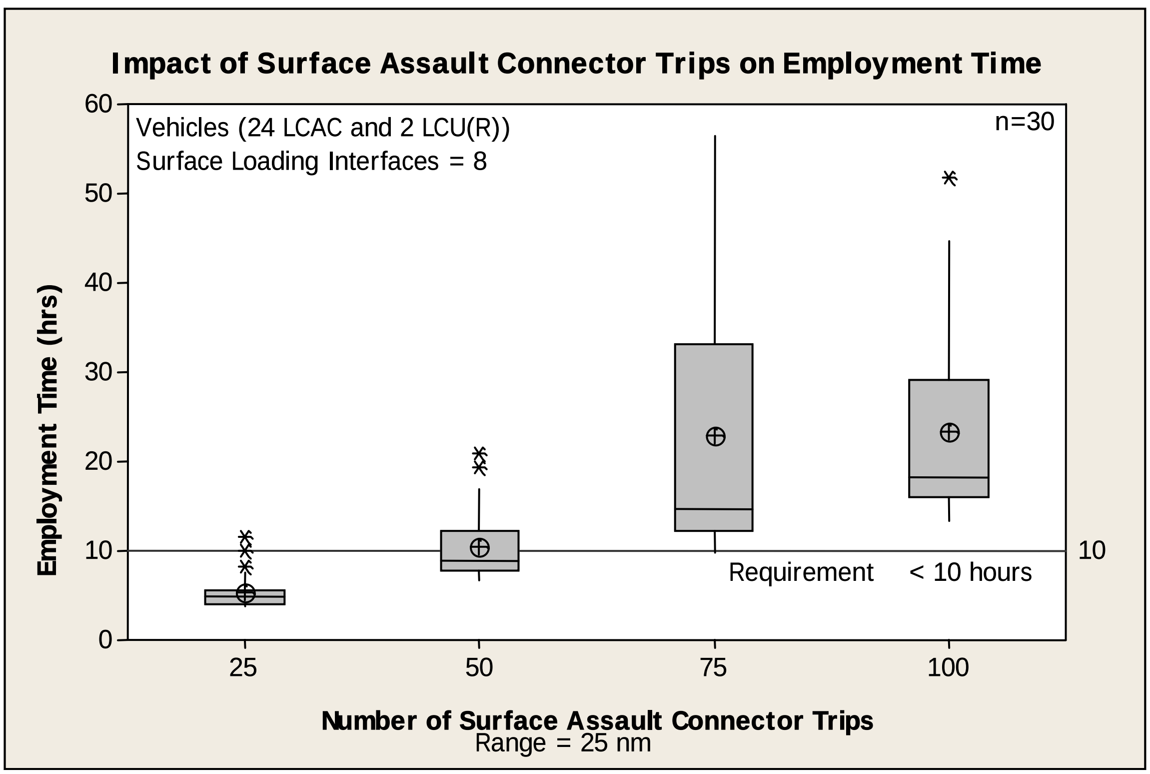


Figure 11-9: Impact of Surface Assault Connector Trips on Employment Time.

11.10.2 Insight

The data suggests that in order to meet the Employment Phase operational time requirement of less than 10 hrs, the total number of trips from the Sea Base must be limited to approximately 50. The number of trips between the Sea Base and beach objective is a key design driver for the Employment Phase. Of all the parameters studied in the sensitivity analysis, only a variation in the quantity of surface assault connector trips allows this operational time requirement to be met. This provides insight into the design of surface connector payload characteristics and the quantity of connectors required. Some possible options to lower the number of trips required include increasing surface connector payload or decreasing the amount (size, weight, area, volume) of equipment required in the surface BLTs.

At greater trip counts (75 and 100), employment time is very unpredictable. There is no significant difference between 75 and 100 trips, with respect to employment time, since the variance for each is so large. This unpredictable performance is a result of the longer employment times interacting with MTBF effects.

11.11 Surface Assault Connector Speed

Surface assault connector speed is varied to determine if speed is a key performance driver during the Employment Phase of operations. Surface assault connector speed is varied between 25 and 55 kts, in increments of 10. Employment range from the Sea Base is 25 NM.

11.11.1 Data

Figure 11-10 depicts the impact of assault connector speed on the time it takes to employ 2 surface BLTs.

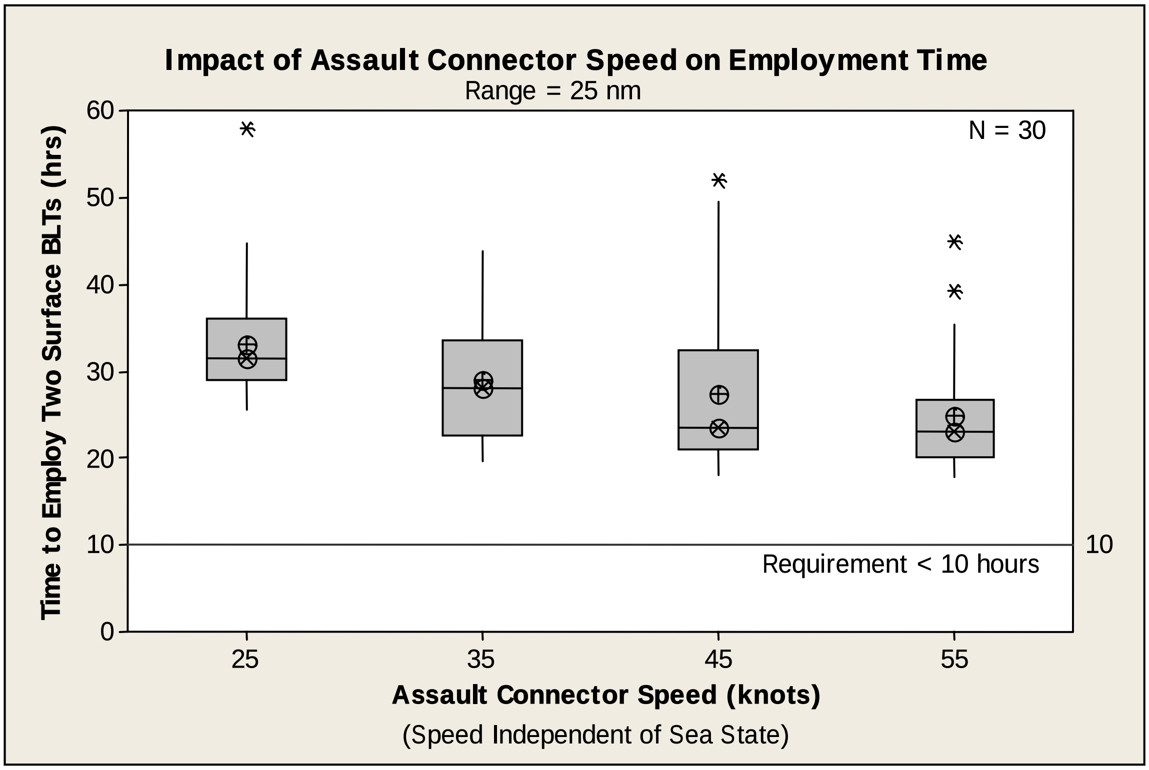


Figure 11-10: Impact of Assault Connector Speed on Employment Time.

11.11.2 Insights

Increasing surface assault connector speed produces minimal performance gains during the Employment Phase from short ranges (25 NM). The largest performance increase occurs between 25 and 35 kts with a 20% reduction in employment time. The performance gains due to speeds between 35 and 45 kts and from 45 to 55 kts are not statistically significant. The data suggests that a marginal, statistically significant (10%) reduction in employment time occurs when speed is increased from 35 to 55 kts. Recommend further sensitivity analysis on the effects of speed on employment time from longer ranges (50 NM to 200 NM) and the interactions between speed, loading times, and the number of ILPs.

11.12 Vertical Sustainment

The quantity of vertical replenishment (VERTREP) aircraft are varied to determine the number of aircraft required to sustain forces ashore from the Sea Base from a distance of 200 NM. The model parameter varied is the number of CH-53X aircraft.

The number of MV-22 aircraft modeled is set to zero since they are unable to provide sustainment in excess of approximately 165 NM (see Chapter 10). CH-53X aircraft operational availability is modeled at approximately 68%, with an MTBF of 40 hrs.

11.12.1 Data

Figure 11-11 depicts the number of CH-53X equivalent aircraft to sustain a brigade-size force ashore from the Sea Base at a distance of 200 NM.

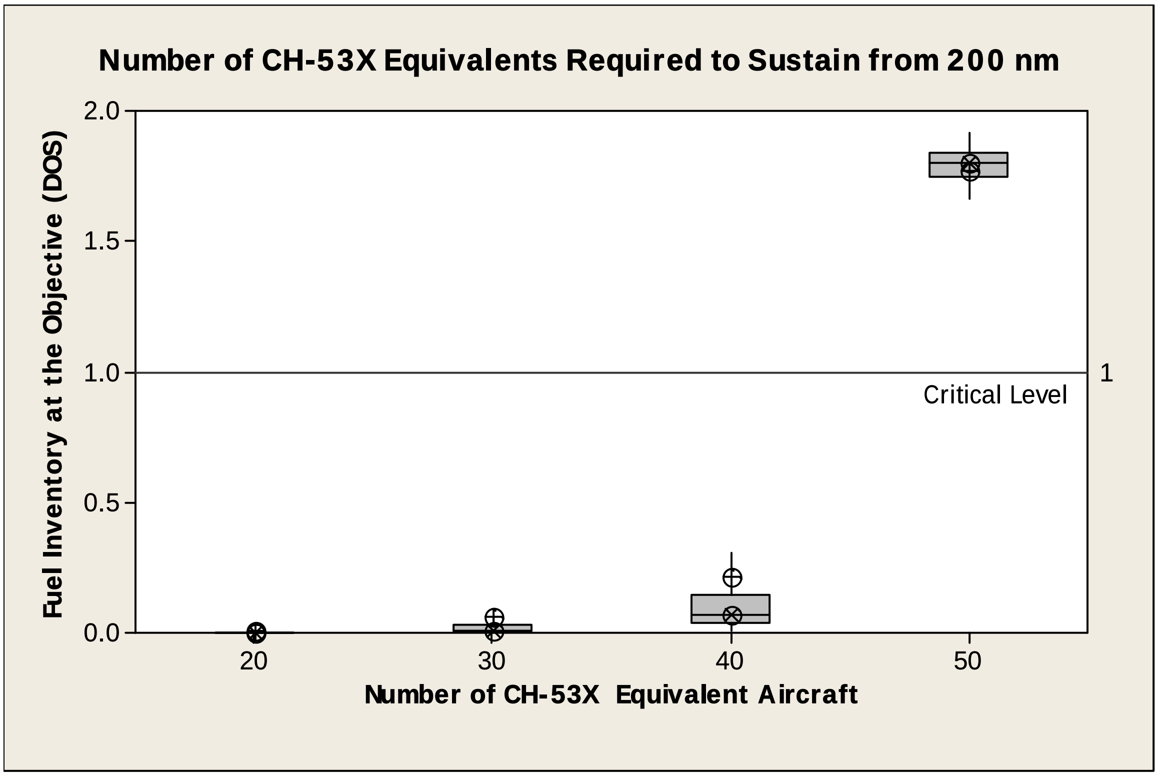


Figure 11-11: Number of CH-53X Equivalent Aircraft to Sustain a JEB-sized Force Ashore from the Sea Base at a Distance of 200 NM.

11.12.2 Insights

The data suggests that, given sufficient heavy-lift aircraft, it is feasible to sustain a Joint Expeditionary Brigade (JEB) from the Sea Base at a distance of 200 NM. Sustainment from a distance of 200 NM requires approximately 50 CH-53X equivalent aircraft that are dedicated to nothing but logistics missions. Additionally, the Sea Base requires less deck space and fewer operational spots to store and operate the 50 CH-53X aircraft in comparison to the 2015 BLA of 20 CH-53X and 48 MV-22 aircraft.

11.13 Summary

Insight into system performance and tendencies gives direction to design alternative architechures to close or eliminate the capability gaps identified in the FNA. The SEABASE-6 model shows what impact surface interfaces, aviation deck spots, connector MTBF, transfer delays at the Sea Base, surface connector speed and cargo capacity, and vertical sustainment at the objective have on the system of systems that comprise the 2015 BLA. The SEABASE-6 model is a product of this study that allows explorations such as these. A fractional factorial designed experiment to fully explore interactions was beyond the scope of this study, but could be conducted as further research using the tools and examples provided here.

12. DESCRIPTIONS, ANALYSIS, AND COST ESTIMATION OF ALTERNATIVE SOLUTIONS

12.1 Overview

The Functional Solution Analysis (FSA) is the third and final phase of the SEA-6 systems engineering project. The FSA helps answer the question, "How can we close or reduce the capability gaps?" The Seabasing and Joint Expeditionary Logistics Operations (JELo) system capability gaps identified in the Functional Needs Analysis (FNA) are the inputs used for the design of alternative architectures. The output of this phase includes designs of alternative architectures intended to close or reduce the capability gaps previously identified in the FNA. Additionally, the cost estimate for each alternative architecture is used for comparative analysis touching the 2015 Baseline Architecture (2015 BLA).

12.2 Methodology

The FSA process begins with a sensitivity analysis of the SEABASE-6 simulation model. Design teams then create alternative architectures to close the capability gaps identified during the FNA by exploiting sensitivity analysis insights. Design teams utilize the Joint Capabilities Integration and Development System (JCIDS) framework to create a balanced and cost effective alternative solution providing synergism across the entire **D**octrine, **O**rganization, **T**raining, **M**ateriel, **L**eadership and education, **P**ersonnel, and **F**acilities (DOTMLPF) trade space. The Burma Scenario then stresses the alternative architectures against the same threat and environmental conditions as the 2015 BLA facilitating a side-by-side comparison. A pair-wise comparison follows for identification of any statistical or militarily significant performance gains and/or reductions in capability gaps. The modeling results and evaluation follow the methodology outlined in Chapter 10, 2015 Baseline Architecture Capability Gaps. The performance of each alternative solution design is then associated with its cost estimate to permit a cost-benefit comparative analysis for the entire solution set to provide conclusions [Chapter 13].

12.2.1 Sensitivity Analysis

It is necessary to perform a sensitivity analysis in order to determine how much of an impact a parameter or group of parameters has on model results. A sensitivity analysis using the SEABASE-6 simulation model provides insight into the Seabasing and JELo system sensitivities, enabling design teams to focus toward specific high impact DOTMLPF changes. For specific sensitivity analysis information and results, refer to Chapter 11.

12.2.2 Design Teams

For the FSA, a format of three competing design teams capitalizes on the competitive nature of the SEA-6 Integrated Project Team. The concept of three competing design teams is used to simulate the current Defense Procurement and Acquisition Policy procedure on the solicitation of Request for Proposals (RFP) for future systems. In this case, the RFP is for 2025 Seabasing JELo architecture to support the Operating Concept in Chapter 2.

12.2.3 2025 Alternative Architecture Design Process

The JCIDS DOTMLPF trade-space establishes the framework from which the three competing design teams formulate their solution sets. The JCIDS framework also specifies a priority of solutions. Alternative architecture designs first focus on nonmateriel solutions to narrow or close capability gaps to prevent unneeded and costly new materiel (M) starts. Existing product improvements are the next priority with expensive and time-consuming new materiel (M) acquisition programs as a final option. Table 12-1 describes the attributes that comprise the DOTMLPF trade-space.

DOTMLPF	Attribute
Doctrine	The doctrine effects or influences on the activities and operations.
Organization	The organization(s) that is responsible for the activities and operations.
Training	The training is what is required to gain the skill-set required to conduct the activities and operations.
Materiel	The materiel is the physical objects required to perform the activities and operations.
Leadership	The leadership is the association with the organizational hierarchy controlling or influencing the activities and operations.
Personnel	The personnel are the actual humans conducting the activities and operations.
Facilities	The facilities are the operational threads that describe the capabilities necessary to perform the activities and operations.

Table 12-1: DOTMLPF Trade-space Attributes.[259]

Due to the large number of conceptual designs under consideration for the 2025 time frame, it is necessary to constrain the set of materiel solutions available to the competing designs teams. A restrictive materiel solution set, known as the M-Pool, contains only materiel solutions that pass at least one of three SEA-6 constraining requirements. For consideration, the materiel solution must be a current Program of Record (PR), an Advanced Concept Demonstrator (ACD), or an Advanced Concept Technology Demonstration (ACTD). The rationale behind this constraint is to prevent inclusion of programs with high technology risk. The premise is that programs/technologies currently funded in 2004 meet the minimum requirements established by Department of Defense science organizations such as the Office of Naval Research and Defense Science Board for feasibility in the 2025 time frame. Table 12-2 lists the materiel solutions that comprise the SEA-6 M-Pool.

[259] Department of Defense Architecture Framework Working Group, DoD Architecture Framework (Version 1.0): Volume I: Definitions and Guidelines, p. 3-17 [instruction online] (30 August 2003) [cited 17 November 2004]); available from World Wide Web @ http://www.teao.saic.com/jfcom/ier/documents/dod_framework_vol_1.pdf.

Materiel Solution	Description
V-44 Future Transport Rotorcraft (FTR)	The V-44 is a future conceptual transport that uses the V-22 tilt rotor concept. Designs envision it to be the size of a C-130 with a quad tilt rotor system that is capable of delivering a payload in excess of 20 tons (internal or external), The design specifications call for a speed capability of over 300 kts and an endurance of over 1,000 NM.
Heavy Landing Craft Air Cushioned (HLCAC)	The HLCAC is set to replace the current LCAC with the first procurement occurring in 2009. The HLCAC will be one-third longer than the LCAC, with twice the payload.
Theater Support Vessel/High Speed Vessel (TSV/HSV)	The TSV/HSV is a high-speed theater transport vessel. Each Service is currently exploring the use of high-speed crafts for use in the littorals. The Navy is also looking at the prospect of using the TSV/HSV to support the Seabasing concept.
Rapid Strategic Lift Ship (RSLS)	The RSLS is a high-speed, strategic lift ship capable of transporting non-self-deploying aircraft and equipment to the Sea Base.
T-AOE(X)	The T-AOE(X) is the future replacement for the current T-AOE. It will exhibit similar resupply capabilities with a slight speed increase.
Advance Theater Transport (ATT)	The ATT is a future technology that incorporates a tilt wing design. It is under review as a future replacement for the C-130 fleet. The design calls for a greater payload than the C-130 with the ability to land on runways less than 500 ft long, including Naval flight decks.
SkyCatTM 1000	The SkyCatTM 1000 is a lighter-than-air technology under consideration by the Department of Defense. Designs include a maximum payload of over 1,100 tons, a maximum speed of 99 kts, and an endurance of 5,000 NM.
Maritime Preposition Force (Future) MPF(F)	The MPF(F) is the future replacement of the current MPF. There are multiple variants under review as potential replacements. For the SEA-6 project, the variants from the CNA MPF(F) study[260] are the primary focus.
Integrated Landing Platform (ILP)	The ILP is envisioned to be the primary surface craft interface point for the MPF(F) and will handle both air cushioned and displacement lighterage for the offloading of various equipment, supplies, and personnel.
AUTOLOG/Extra Heavy Lift Underway Replenishment System	The AUTOLOG/Extra Heavy Lift transfer system of systems is composed of two separate subsystems: the Autolog intra-ship transfer system and the Extra Heavy Lift inter-ship transfer system. The Autolog intra-ship transfer system locates, connects, lifts, and transports cargo containers from their storage position on the container vessel to the Extra Heavy Lift Connected Replenishment (CONREP) transfer station. The Extra Heavy Lift Transfer System then connects to the cargo container and transfers it by tensioned high wire to the receiving ship.
Affordable Guided Air Drop System (AGAS)	AGAS is a program that enables supplies delivery via parachutes from Air Force aircraft such as C-130s and C-17s. Current prototypes can handle weights up to 2,100 lbs, but future designs are aiming to deliver a fully loaded Joint Modular Intermodal Container (JMIC) to personnel ashore.
Partial Air-Cushioned Support Catamaran (PACSCAT)	PACSCAT vessel is a fast, freight-carrying, slender-hulled catamaran. It is designed to operate on inland waterways and on short-sea routes. Current designs of the vessel have an overall length of 135 m and a beam of 22.8 m. They can provide deadweight transport of up to 2,200 T with a cargo capacity of up to 240 TEU. LO/LO and RO/RO configurations are both under development.
LHA(R)	The LHA Replacement (LHA(R)) Program is the functional replacement for USS TARAWA (LHA 1) Class ships. It is planned as an affordable and sustainable Amphibious Ship development program in support of the Navy and Marine Corps Global Concept of Operations.
Navy Storage and Retrieval System (NAVSTORS)	NAVSTORS is a fully automated shipboard stowage and retrieval system designed to perform cargo and weapons handling operations in the holds and magazines in NIMITZ-class and CVN(X) aircraft carriers, with possible future applications in DD(X), CG(X), and LCS.

Table 12-2: List of Available Materiel Solutions for 2025 Alternative Architecture Designs (M-Pool).

[260] Robert M. Sounders, Suzanne Schulze, Yana Ginburg, and John Goetke, “MPF(F) Analysis of Alternatives: Final Report,” (Alexandria, VA: The CNA Corporation, CNR D00009814.A2/Final April 2002), pp. 29-48.

In addition to the materiel options in the M-Pool, an additional academic materiel technology inject is evaluated. The academic technology inject is imposed to facilitate cross-campus interdisciplinary participation by the Total Ship Systems Engineering (TSSE) group. The TSSE materiel solution consists of a Joint Amphibious Combat Cargo Expeditionary Support Ship design (Joint ACCESS). Appendix E contains detailed information regarding the Joint ACCESS. To ensure the use of the Joint ACCESS, Design Team I incorporates the Joint ACCESS for evaluation in their 2025 Alternative Architecture I. Additionally, the Rapid Strategic Lift Ship (RSLS) is currently a high interest materiel solution being evaluated by OPNAV and NAVSEA. To evaluate the potential of the RSLS, Design Team II incorporates the RSLS into their 2025 Alternative Architecture II. The unrestricted use of nonmateriel trade space solutions is available to all designs teams. For design solutions, each team assumes a 2025 JEB is equivalent to the 2015 JEB outlined in Chapter 5.

12.2.4 2025 Alternative Architecture Performance

The evaluation process to determine the 2025 Alternative Architectures system performance is identical to that of the 2015 BLA. The SEABASE-6 simulation model is used to evaluate each alternative architecture. The Burma Scenario, outlined in Chapter 9, provides the operational and environmental context for the evaluation. Thirty simulation runs for each alternative architecture provides data for follow-on statistical analysis.

The SEABASE-6 Extend™ model provides the means to assess the three 2025 Alternative Architectures using the methodology detailed in Chapter 10. Comparisons of the simulation results are performed against the Critical Operational Issues (COIs) to determine whether the COI is met, or whether there is performance shortfalls identifying a capability gap.

12.2.5 Comparative Analysis

The comparative analysis overall goal is to determine if the performance of each 2025 Alternative Architecture is successful in closing the gaps identified in the 2015 BLA.

The first step compares the MOE/MOP results of the 2025 Alternative Architectures with those of the 2015 BLA. A 2025 Alternative Architecture gap analysis is necessary to determine if there is a reduction in the existing baseline capability gaps and to identify any new emerging gaps. Comparative analysis between each alternative design and the 2015 BLA provides insight as to whether the 2025 Alternative Architecture demonstrates a statistically significant improvement. MOE/MOP comparisons for each operational phase (closure, employment, and sustainment) are also necessary in evaluating the overall Seabasing and JELo system performance for each 2025 Alternative Architecture design.

12.3 2025 Alternative Architecture I

Alternative Architecture I utilizes the design of the Total Ships Systems Engineering (TSSE) Joint Amphibious Combat Cargo Expeditionary Support Ship (Joint ACCESS) High Speed Assault Connector (HSAC) as the primary materiel solution design for changes to the 2015 BLA. The Joint ACCESS is a self-deployable ship primarily employed to deliver the two surface Battalion Landing Teams (BLT) directly from the Forward Logistics Site (FLS) to the beach. Appendix F contains a more detailed description of the Joint ACCESS design. Joint ACCESS, shown in Figure 12-1, incorporates the following attributes:

- Over 500 ft in length
- 43 kts cruise speed
- 2,000-NM range
- 800-ton payload capability
- 260-troop berthing
- Manning of 60 to 70 personnel

- Two cargo decks
- Hanger for a single SH-60
- One helicopter operational spot for SH-60, CH-53X, or MV-22
- Elevator from cargo deck to hanger
- 20-day self-sustainment
- Capable of at-sea replenishment
- Gas turbine engines with water jets
- Beachable with a 120-ft bow ramp
- Self-defense weapon systems and beach landing support systems

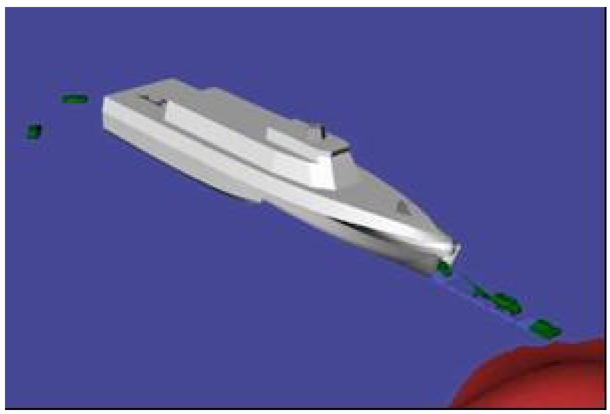


Figure 12-1: TSSE Joint ACCESS Design.

Table 12-3 summarizes Design Team I's Alternative Architecture to include Sea Base operational roles and changes from the 2015 BLA.

Platform	Number	Joint Expeditionary Logistics Operation (JELo) Phase	Changes from the 2015 BLA
MPF(F) Unconstrained-size, distributed-capability ships[261]	2	Closure/Employment/Sustainment	Eliminated 6 ships
Afloat Forward Staging Base (AFSB) MPF(F) variant ship[262]	2	Closure/Employment/Sustainment	Addition
Joint ACCESS	12	Employment/Sustainment	Addition
MV-22	48	Employment/Sustainment	None
CH-53X	20	Employment/Sustainment	None
SH-60R	12	Sustainment	None
AH-1Z	18	Sea Strike	None
VTUAV	6	Sea Strike	None
JSF	36	Sea Strike	None
CLF Tanker	1	Sustainment	None
UH-1Y	0	MEDEVAC	Eliminated
LCAC	0	Employment	Eliminated
LCU(R)	0	Employment	Eliminated

Table 12-3: 2025 Alternative Architecture I Composition.

12.3.1 2025 Alternative Architecture I Nonmateriel Design Changes

Table 12-4 describes the nonmateriel changes made to 2025 Alternative Architecture I compared to the 2015 BLA.

2025 Alternative Architecture I Nonmateriel Changes	
Doctrine	1. Assemble CH-53Xs in-transit from FLS to objective onboard MPF(F) vessels. This is accomplished by loading the aircraft on the MPF(F) as they arrive at the FLS: a) In the 2015 Baseline model, the aircraft arrive at the FLS by C-17, reassemble, and then fly onto the MPF(F). This creates a time delay of 3+ days, contributing to the closure gap described in Chapter 10. b) This change addresses the closure gap. c) The change is made with time/space analysis and expert opinion considering the ability of the CH-53X aircraft to be reassembled and to conduct a functional check flight at sea. 2. Use only MV-22s for MEDEVAC: a) In the baseline model, all aircraft are used for MEDEVAC with the UH-1Y designated as the primary MEDEVAC aircraft. b) The UH-1Y does not have the range and speed to meet the SEA-6 established requirement, which results in the change. The MV-22 has a longer range and greater speed than the UH-1Y. In addition, the MV-22 can also transport more litters and injured patients than the UH-1Y. Since the MV-22 is a supply transport during the Sustainment Phase, it can divert quickly to a MEDEVAC mission prior to returning to the Sea Base.
Organization	None
Training	None

[261] Robert M. Sounders, Suzanne Schulze, Yana Ginburg, and John Goetke, "MPF(F) Analysis of Alternatives: Final Report," (Alexandria, VA: The CNA Corporation, CNR D00009814.A2/Final April 2002), p. 33.
[262] Ibid., p. 46.

2025 Alternative Architecture I Nonmateriel Changes	
Leadership	None
Personnel	None
Facilities	1. MPF(F) storage area: 2025 Alternative Architecture I increases the available MPF(F) storage utilization from 48% to 60%. With the use of selective offloading, the 2015 BLA only utilizes 48% of the available cargo space. Since the Joint ACCESS transports the two surface BLTs, the remaining equipment and vehicles carried onboard the MPF(F) ships does not require selective off-load, resulting in an increase of storage utilization. 2. Forward deployment of the Joint ACCESS squadron to the FLS requires infrastructure to be in place to support the squadron.

Table 12-4: 2025 Alternative Architecture I Non-Materiel Changes.

12.3.2 2025 Alternative Architecture I Materiel Design Changes

The first part of the Closure Phase is the movement of assets from the Advance Base, defined as Okinawa in the Burma Scenario, to the FLS. The only change to this part of the Closure Phase is the elimination of the UH-1Y Iroquois. The UH-1Y is eliminated due to its insufficient range and speed in support of the MEDEVAC mission. The MV-22 replaces the UH-1Y as the primary MEDEVAC platform.

The second part of the Closure phase is the movement of the Sea Base assets from the FLS to the Sea Base. Design Team I, with the addition of 12 Joint ACCESS ships, made significant changes to the 2015 BLA. Twelve Joint ACCESS platforms are capable of transporting the two surface Sea Base Maneuver Elements (SBME) BLTs [Chapter 5] to the beach in a single trip. This materiel solution eliminates the difficulties with at-sea transfers and dramatically reduces the number of trips required to employ the forces. The result of embarking the two surface BLT's equipment in the Joint ACCESS platforms results in a requirements change for the number of MPF(F). Analysis indicates the requirement for the number of MPF(F) unconstrained-size, distributed-capability ships is reduced from 8 down to 2, with the addition of 2 Afloat Forward Staging Base (AFSB) ships.

Figure 12-2: AFSB MPF(F) Ship.[263]

Figure 12-2 shows the AFSB MPF(F) ship and Tables 12-5 and 12-6 show the AFSB characteristics. The AFSB has 11 operational spots for normal air operations; however, only 7 are used. The other 4 operational spots are required as additional aircraft parking spots.

Characteristic	Dimension
Length overall	949 ft
Maximum beam	126 ft
Full load draft	31.5 ft
Lightship tonnage	40,319 MT
Full-load tonnage	TBD
Full time MSC crew	45 personnel
USMC accommodations	2,000 personnel
Cargo fuel	33,000 bbls
Cargo square	33,000 sq ft
Cargo area	30,000 sq ft
# of containers	N/A
Aviation stowage and maintenance space	173,000 sq ft
CH-46 equivalent parking spots	80
CH-53X operational spots	11
LCAC stows	0
Craft interface	0

Table 12-5: AFSB MPF(F) Ship Characteristics.[264]

[263] Ibid., p. 47.
[264] Ibid., p. 48.

AFSB Ship Characteristics	
Personnel berthing space	2,000 people
Vehicle cargo space	33,000 sq ft
Combat gear space (nonvehicle)	30,000 sq ft
Aircraft storage space	108,700 sq ft
Surface craft storage space	0
Medical space	5,000 sq ft
Maintenance space	50,000 sq ft
Assembly space	7,000 sq ft
Fuel space	33,000 bbls
Interface (Surface)	0
Interface (Vertical)	11
Water production	500,000 gal/day
Additional Squadron Requirements	
Non-Prepositioned cargo	3,000 tons
JTFC Staff Personnel	500 people
JTFC Staff space	30,000 sq ft
MEB C2 space	30,000 sq ft (split across 2 ships)

Table 12-6: AFSB MPF(F) Ship Characteristics.[265]

The two AFSB ships provide the required area, volume, and weight capability to supplement the 2 unconstrained-size, distributed-capability ships, while providing the additional aircraft operational and parking spots needed to fill the gap caused by reducing the number of MPF(F) ships from 8 to 2. Table 12-7 is a summary of Design Team I's MPF(F) load-out distribution.

[265] Ibid., p. 48.

	UNITS	UNCON-1	UNCON-2	AFSB-1	AFSB-2	TOTALS
FOOD	Area (sq ft)	2,464	2,464	2,463	2,463	9,854
	Weight (stons)	102	102	102	102	408
WATER	Area (sq ft)	15,800	15,800	7,914	7,914	47,428
	Weight (stons)	1,411	1,411	707	707	4,236
	Volume (gal)	340,083	340,083	170,328	170,328	1,020,822
AMMO	Area (sq ft)	18,554	18,554	6,650	6,650	50,408
	Weight (stons)	2,485	2,485	890	890	6,750
FUEL	Volume (gal)	1,873,200	1,873,200	1,386,000	1,386,000	6,518,400
SBSE	Area (sq ft)	115,402	115,402	50,000	50,000	330,804
	Weight (stons)	3,195	3,195	1,384	1,384	9,158
FIE	Area (sq ft)	30,644	30,664	10,010	10,010	81,328
	Weight (stons)	666	666	218	218	1,768
AIRCRAFT	Operational spots	2	2	7	7	18
	Parking spots	47	47	84	84	262
	Maintenance spots	Unknown	Unknown	Unknown	Unknown	Unknown
TOTALS	Area (sq ft)	182,864	182,884	77,037	77,037	519,822
	Weight (stons)	7,859	7,859	3,301	3,301	22,320
AIRCRAFT	MV-22	12(27)	12(27)	12(27)	12(27)	48(108)
	CH-53X			10(27)	10(27)	20(54)
	AH-1	10(10)		4(4)	4(4)	18(18)
	SH-60	10(9)				10(9)
	JSF		10(21)	13(27)	13(27)	36(75)
NOTE: Numbers in parentheses are required aircraft parking spots.						

Table 12-7: 2025 Alternative Architecture I MPF(F) Load-out Distribution.

In the Sea Base operation's Employment Phase, the use of the 12 Joint ACCESSs eliminates the need for LCAC and LCU(R) assault surface connectors. The 12 Joint ACCESS platforms are capable of completing the employment and disembarkation of the two surface BLTs within the established 10-hr requirement.

For the ashore Sustainment phase, Design Team I made no materiel changes from the 2015 BLA. The team continued to employ the CH-53X and MV-22 as the transport systems for delivering provisions, fuel, and ammunition to the objective.

For the Sea Base Sustainment phase, the design team employs the Joint ACCESS as a high-speed shuttle ship between the FLS and the Sea Base and a T-AOE for Sea Base refueling. The Joint ACCESS, after completing the Employment Phase, resupplies the Sea Base with ammunition and provisions. Six Joint ACCESS vessels can transport sufficient amounts of these supplies to keep the Sea Base inventory above

reserve requirements. The actual amounts carried are 80,000 lbs of provisions, 84,939 gallons of bottled water, and 715,000 lbs of ammunition. The Joint ACCESS transfers supplies to the MPF(F) ships via vertical and connected replenishment. Utilizing both of these methods of transfer, the at-sea replenishment lasts approximately 4 hrs. The vertical replenishment employs the SH-60R helicopters at an assumed transfer rate of 60,000 lbs/hr. The assumed connected replenishment transfer rate is 26,000 lbs/hr.

The only requirement not met in resupplying the Sea Base with the use of the Joint ACCESS is the fuel criteria. To sustain fueling requirements, the use of a fuel tanker is incorporated.

12.4 2025 Alternative Architecture I Concept of Operations

Utilizing the 2025 Alternative Architecture I composition to generate an operational view, the following Concept of Operation emerges. Figure 12-2 depicts the JELo Operational Concept Graphic (OV-1). The Advance Base (Okinawa), not shown in Figure 12-2, is the initial starting point of the operation. From the Advance Base, non-self-deploying aircraft and JEB personnel depart for transit to the FLS. The FLS, shown in the distance, represents the starting point for the Maritime Prepositioning Group (MPG). The MPG consists of 4 MPF(F)s, a CLF, and 12 Joint ACCESS ships. The MPF(F)s carry the vertical BLT personnel and equipment from the FLS to the Sea Base. Joint ACCESS is the assault connector that transports the 2 surface BLTs to the beach and then acts as a high-speed shuttle ship to resupply the Sea Base. The CLF tanker is the refueling asset for the Sea Base. The aircraft represent the connectors that provide vertical BLT insertion and logistical support between the MPG and objective. The lightening bolts represent the C2 system linking all assets together. The single CSG/ESG represents the inclusion of CSGs and ESGs within the Sea Base.

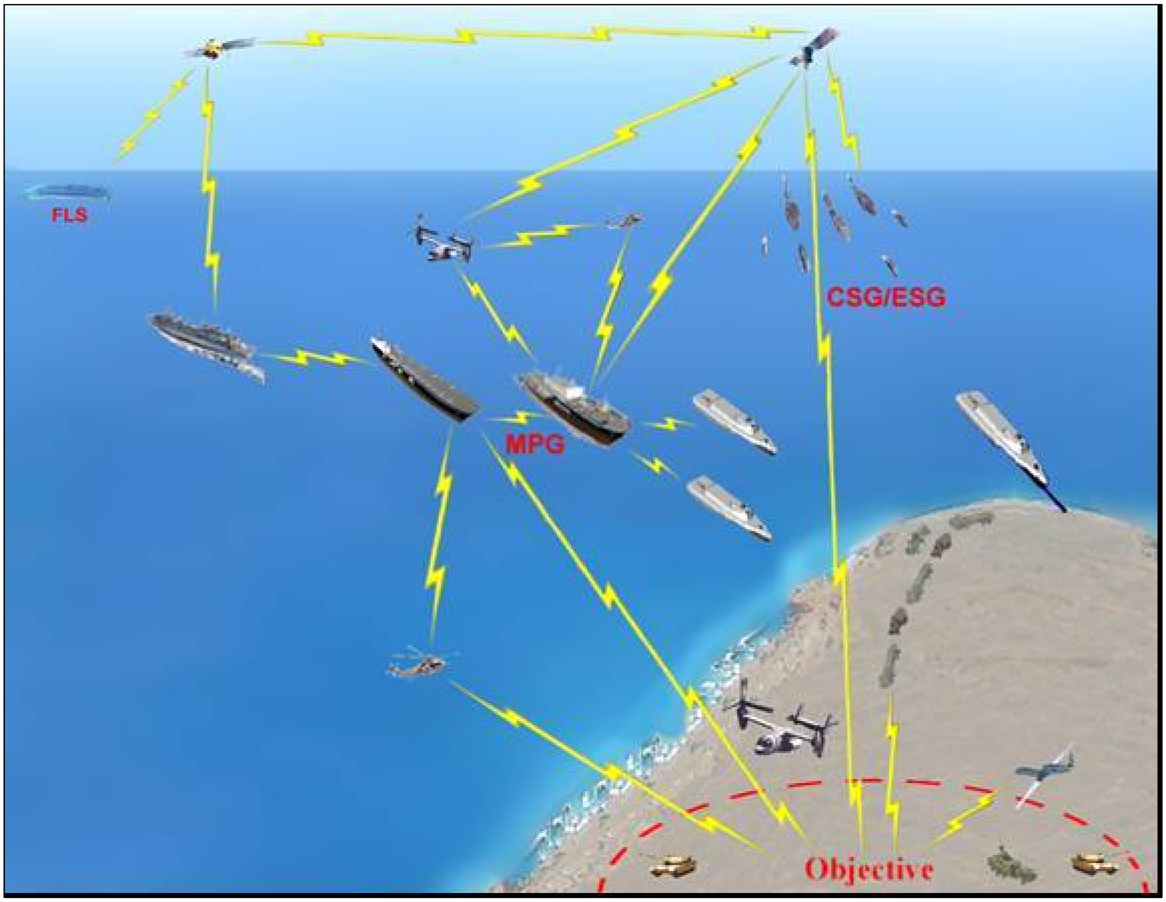


Figure 12-3: 2025 Alternative Architecture I Operational View (OV-1).

12.4.1 Closure Phase

The Closure Phase consists of deployment, transit, assembly of personnel and equipment, and the Sea Base formation. The Closure Phase begins with the movement of personnel and non-self-deploying aircraft to the FLS. The Joint ACCESS and MPF(F) ships are assumed to be prepositioned at the FLS.

For personnel movement, 2025 Alternative Architecture I relies on the use of Civil Reserve Air Fleet (CRAF) to transport the JEB personnel from point of origin to the designated FLS. The same assumptions for the 2015 BLA apply to the 2025 Alternative Architecture I.

For the movement of non-self-deploying aircraft, 2025 Alternative Architecture I also uses the same 2015 BLA assumptions for the movement and transportation of both

self-deploying aircraft and non-self-deploying aircraft. Non-self-deploying aircraft rely on the U.S. Air Force Air Mobility Command (AMC) for transportation.

Assembly occurs similar to the 2015 BLA, with one major difference. 2025 Alternative Architecture I changes the reassembly location of the CH-53X aircraft from the FLS to the MPF(F). Following their delivery to the FLS, the CH-53Xs are craned onboard the MPF(F) without assembly. While in-transit to the Sea Base, the CH-53Xs are reassembled and all check flights are performed prior to arrival at the Sea Base.

12.4.2 Employment Phase

The movement of equipment designated for air transport is similar to the 2015 BLA and as specified in Chapter 5 [Enclosure 1B] landing priorities 1-8. The Joint ACCESS transports the equipment designated for movement via surface transport in a single wave and as specified in Chapter 5 [Enclosure 1A], landing priorities 1-19.

The remaining equipment is detailed in Chapter 5 [Enclosure 1A], landing priorities 20-28 is delivered by Joint ACCESS platforms from the MPF(F) and landing priorities 9 and 10 by vertical means. The transport of the remaining priorities occurs immediately following the initial equipment movement.

12.4.3 Sustainment Phase

Resupply at the objective occurs in the same manner as the 2015 BLA. Sea Base resupply occurs using the Joint ACCESS. Joint ACCESS has one operational helicopter spot that will support the use of the SH-60R to transfer supplies via vertical replenishment. Joint ACCESS is also equipped with connected replenishment equipment to supplement the SH-60R during at-sea replenishment of the Sea Base. A cargo fuel delivery ship is still required in this architecture since the Joint ACCESS cannot support that role.

12.4.4 Medical Evacuation

The MV-22 is the sole asset used to conduct the MEDEVAC mission. In addition to delivering supplies to the objective, the MV-22, after delivery of its cargo, checks for casualties prior to returning to the Sea Base.

12.4.5 Cost Estimation of 2025 Alternative Architecture I

Table 12-8 is a cost estimate summary for the 2025 Alternative Architecture I. The cost estimate contains acquisition cost data and ten years of operating and support (O & S) cost data. Calculations to determine the cost estimate are similar to those from Chapter 7, Baseline Architecture Cost Estimation Analysis. Example cost estimate calculations are in Appendix C. Cost data are normalized using the inflation indices provided by the Naval Cost Analysis Division (NCAD) to account for inflation and the time value of money[266] and is provided in FY04$.

Platform	Quantity	Acquisition Cost (FY04$)	10 Years of O&S Costs (FY04$)	Total Cost (FY04$)
MPF(F) - Baseline variant	2	$4,001,185,185	$1,126,187,290	$5,127,372,475
MPF(F) - AFSB variant	2	$2,769,095,806	$1,126,187,290	$3,895,283,096
ACCESS	12	$5,703,571,968	$55,479,072	$5,759,051,040
T-AOE	1	$739,106,413	$868,543,070	$1,607,649,483
MV-22	48	$3,792,336,000	$2,578,714,848	$6,371,050,848
CH-53X	20	$1,099,073,220	$440,754,300	$1,539,827,520
SH-60R	14	$510,666,167	$639,456,300	$1,150,122,467
AH-1Z	18	$362,701,736	$600,539,040	$963,240,776
JSF (F-35)	36	$2,994,231,545	$2,002,489,920	$4,996,721,465
VTUAV	6	$11,049,804	$77,348,820	$88,398,624
Total Cost		$21,983,017,844	$9,515,699,950	$31,498,717,794

Table 12-8: 2025 Alternative Architecture I Cost Estimation.

Cost estimation data for each MPF(F) is from the Center for Naval Analysis MPF(F) study.[267] The acquisition cost data for the Joint ACCESS is from the

[266] Inflation indices are from the Navy Cost Analysis Division (NCAD) and are located at http://www.ncca.navy.mil/services/inflation.cfm.
[267] Robert M. Souders, Suzanne Schulze, Yana Ginburg, and John Goetke, "MPF(F) Analysis of Alternatives: Final Summary Report," (Alexandria, VA: The CNA Corporation, CNR D0009814.A2/Final April 2004), pp. 48-54.

TSSE design team cost estimation. For Joint ACCESS O & S cost calculations, an analogy approach using a frigate (FFG) based on vessel size is performed.[268]

12.5 2025 Alternative Architecture I Modeling Results and Evaluation

Of the eight Critical Operational Issues (COIs) addressed, 2025 Alternative Architecture I successfully meets the requirements of four. The specific answers to each COI, as evaluated from the scenario simulation, follow in the details below.

12.5.1 Closure Phase

The Closure Phase involves the deployment, transit, assembly of personnel and aircraft, and the Sea Base formation. There are three COIs that address the Closure Phase. COI 1 addresses the delivery of the Sea Base Maneuver Element (SBME) and the Sea Base Support Element (SBSE) to the Forward Logistics Site (FLS) in time to meet the 10-day requirement. COI 2 involves the loading of the SBME and the SBSE aboard the MPF(F) in time to meet the 10-day requirement. COI 3 addresses the MPF(F) vessels ability to get underway from the FLS in time to meet the 10-day requirement.

For the Closure Phase, 2025 Alternative Architecture I does not meet the requirement. Analysis reveals the alternative architecture does reduce the capability gap from the 2015 BLA by 3 days, but a 3-day capability gap still exists. The reduction is attributed to the nonmateriel change of reassembling the CH-53Xs while in-transit to the Sea Base vice at the FLS. However, the reassembly of CH-53X change cannot overcome the 96-hr delay caused by the formation of the air bridge. The 96-hr air bridge delay adversely affects the ability to meet the requirements for COIs 1, 2, and 3. Figure 12-4 depicts the 2025 Alternative Architecture I performance during the Closure Phase.

[268] All O & S cost data is from the Navy Visibility and Management of Operating and Support Costs (VAMOSC) management information system. VAMOSC is a restricted access system. To access, permission must be granted by the Navy Cost Analysis Division (NCAD). The VAMOSC system is located at http://www.navyvamosc.com/.

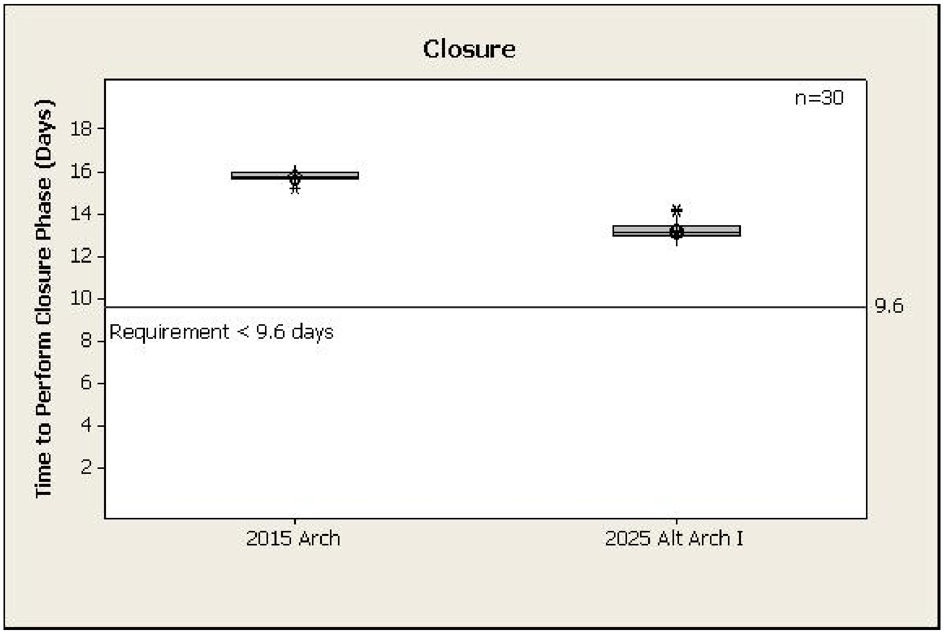


Figure 12-4: Time to Complete Closure Phase for 2025 Alternative Architecture I.

12.5.2 Employment Phase

The Employment Phase involves delivering 2 surface BLTs and 1 vertical BLT within a 10-hr period. Air assault connectors deliver the 1 vertical BLT, while surface assault connectors (Joint ACCESS) deliver the remaining 2 surface BLTs.

COI 5 involves the employment of the SBME to an objective. The goal for accomplishing this operation is a 10-hr period. 2025 Alternative Architecture I deploys the SMBE to the objective in 10.1 hrs. Joint ACCESS completes the employment of the 2 surface BLTs in 6.7 hrs. The insertion of the vertical BLT prevents a quicker Employment Phase. On average, the CH-53X completes the Vertical Employment Phase in 10.1 hrs. From the 30 simulation runs, Figure 12-5 indicates 2025 Alternative Architecture I successfully delivers the SBME to the objective 77% of the time (23 out of 30 runs).

Two factors affect the ability to achieve 100% employment success. The first factor is a model artifact regarding attrition. In the SEABASE-6 model, 12 deliveries to the objective are required for the model to recognize the completion of the surface component of the Employment Phase. If one Joint ACCESS is lost due to enemy

intervention, the model assumes one of the empty Joint ACCESSs will return to the Sea Base for reloading. Once it loads, the Joint ACCESS returns to the objective for off-load. This return trip accounts for the variation in the 10-hr requirement. The second factor pertains to the maintenance of the CH-53X. During the SEABASE-6 simulation, the average time a CH-53X spends in a queuing status while waiting for maintenance is 1.3 hrs. This equates to at least six CH-53Xs requiring maintenance during the Employment Phase. This maintenance queue results in fewer CH-53Xs available to complete the Employment Phase and increases the average time for employment.

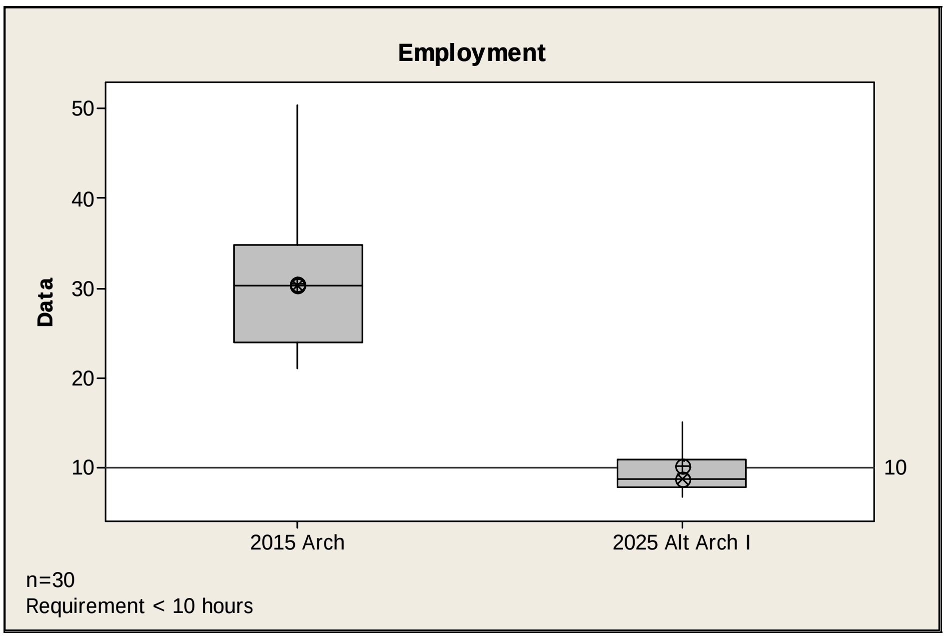


Figure 12-5: Employment of the SBME at the Objective for 2025 Alternative Architecture I.

12.5.3 Seize the Initiative

In accordance with the Operating Concept [Chapter 2], the force has 10 days to seize the initiative. In order to seize the initiative, the 2025 Alternative Architecture I must complete the Closure, Assembly, and Employment Phases of operations within 10 days. COI 6 provides insight into this system requirement.

COI 6 involves the delivery of a JEB from the Advance Base (Okinawa) to the FLS and then to the Sea Base to include employing 2 surface BLTs to the beach and 1 vertical BLT at the objective with a goal of 10 days (240 hrs). 2025 Alternative

Architecture I fails to meet the requirements of 10 days, with an average time of 13 days. The inability to meet COI 6 is attributed to the inability to meet the Closure Phase requirement.

12.5.4 Sustainment Phase

The Sustainment Phase involves delivering supplies vertically from the Sea Base to the objective for a mission time of 30 days. Additionally, during the 30-day mission time, a resupply shuttle ship must also sustain the Sea Base. COIs 7 and 8 provide the sustainment information needed for both the Sea Base and objective to evaluate this system requirement.

COI 7 first addresses sustainment of the Sea Base for a minimum of 30 days (720 hrs). In 2025 Alternative Architecture I, no class of supply reaches exhaustion. With Joint ACCESS in its resupply shuttle role, the Sea Base is able to maintain supplies above the reserve level. There are instances when the reserve level for supplies at the Sea Base for provisions and fuel falls below the requirement, as shown in Figures 12-6 and 12-7. However, resupply occurs quickly, avoiding an impact on operations at the objective.

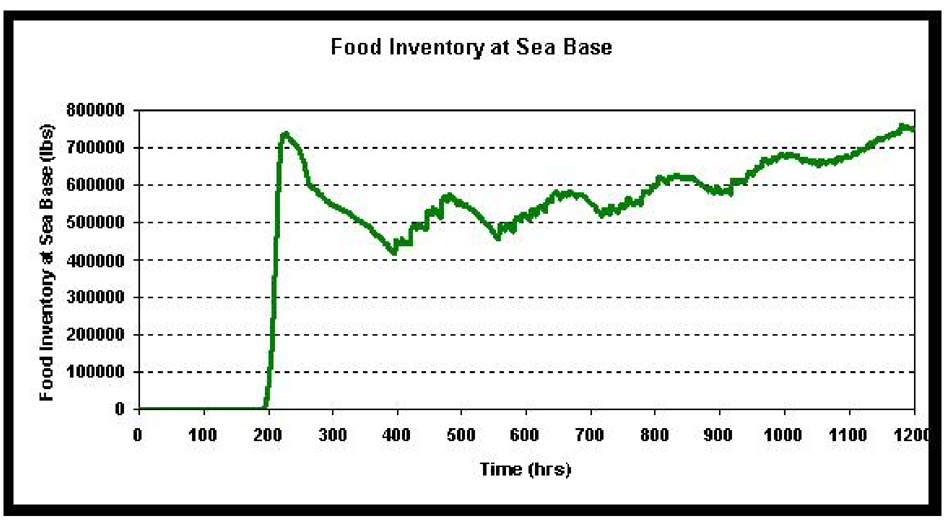


Figure 12-6: Sea Base Provisions Sustainment for 2025 Alternative Architecture I.

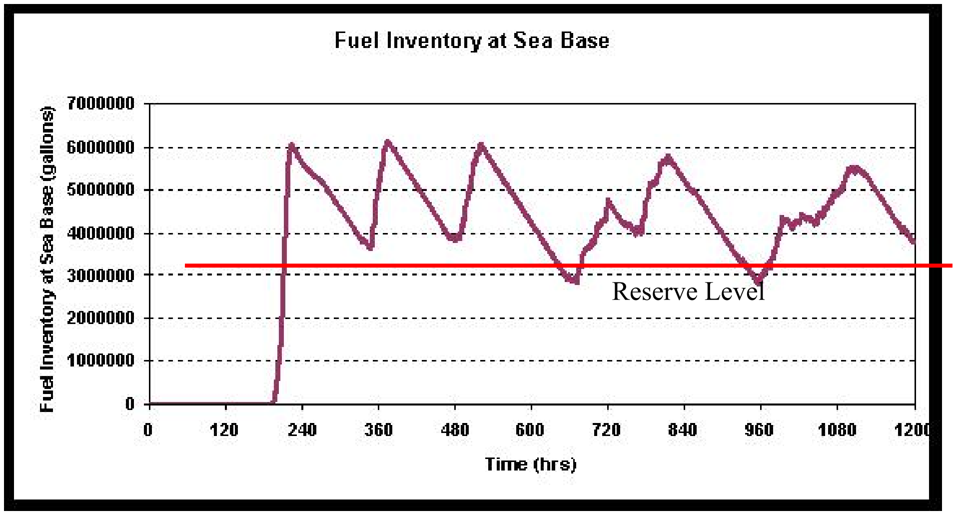


Figure 12-7: Sea Base Fuel Sustainment for 2025 Alternative Architecture I.

COI 7 also addresses the objective sustainment. Objective sustainment involves sustaining the JEB from the sea for a minimum of 30 days (720 hrs). In 2025 Alternative Architecture I, no class of supply is ever fully exhausted or falls below the critical reserve level during the Sustainment Phase. COI 7 also permits an evaluation of the maximum distribution capacity of the SBME. Analysis reveals that an overabundant amount of provisions is sent to the objective from the Sea Base. Figure 12-8 indicates that during the initial start of the Sustainment Phase, an oversupply of provisions occurs. This occurs due to a model artificiality, in which air connectors begin delivering supplies prior to the exhaustion of the initial supplies delivered during the Employment Phase.

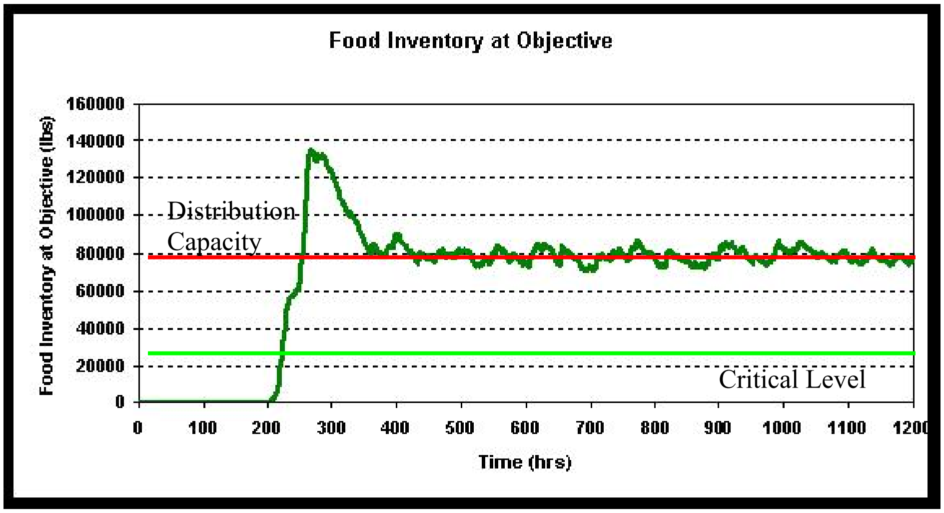


Figure 12-8: Provisions Inventory at the Objective during the Sustainment Phase for 2025 Alternative Architecture I.

COI 8 addresses the sustainment of the JEB by vertical lift only. The total range from Sea Base to objective for the scenario is 150 NM, which is just under the 165 NM maximum range of the MV-22 with external cargo loads. If the 165 NM range of the MV-22 is exceeded, the 20 CH-53Xs are not capable of meeting the sustainment demands of the ashore forces by themselves. Sensitivity analysis indicates that to provide vertical sustainment between 165 and 200 NM, approximately 50 CH-53Xs are required.

12.5.5 Medical Evacuation

COI 9 involves the medical evacuation (MEDEVAC) of wounded personnel within the Golden Hour (defined in Chapter 2). In 2025 Alternative Architecture I, the doctrine change from using the UH-1Y as the primary MEDEVAC platform to assigning only the MV-22 MEDEVAC results in meeting this requirement. On average, 2025 Alternative Architecture I can perform MEDEVAC operations from the objective to the Sea Base within 30 minutes.

12.5.6 Summary

Though the 2025 Alternative Architecture I fails to meet the requirements for each COI, it does provide valuable insights. The nonmateriel trade space change to the assembly of the CH-53Xs while in-transit to the Sea Base provides a valuable time

savings. However, this time savings is not enough to overcome the 96-hr air bridge formation delay. The Joint ACCESS provides the capability to land all necessary personnel and equipment for two surface BLTs, eliminating at-sea personnel and equipment transfers and the need for multiple trips. In addition to providing rapid assault capabilities, the Joint ACCESS also provides a means to ensure the resupply of the Sea Base during the Sustainment Phase.

12.6 2025 Alternative Architecture I Potential New Issues Created

Joint ACCESS platforms are all loaded with the critical vehicles and equipment of the JEB requiring that Joint ACCESS has the same reliability, availability, and maintainability requirements as the MPF(F) ships. These requirements mean that the architecture cannot have any of these systems fail during the Closure and Employment Phases of the operation. Joint ACCESS is also more susceptible to attack due to the time it must stay close to the beach disembarking. However, this susceptibility is mitigated since Joint ACCESS is more survivable than a LCAC or LCU(R). In addition, the single trip by the Joint ACCESS squadron provides fewer exposures to the enemy than the multiple trips required by the LCACs and LCU(R)s. Joint ACCESS has its own self-defense weapon systems to counter enemy threats while offloading personnel and equipment.

Following the initial employment, Joint ACCESS returns to the MPF(F) to load and transport the remaining nonpriority vehicles and equipment to the objective via an ILP. If the sea conditions exceed sea state 3, ILP transfer operations cannot proceed, restricting the delivery of vehicles and equipment to the objective. The time requirement to load the Joint ACCESS via ILP is much greater than loading an LCAC, and with only 2 of these ships available, there are only 2 transfer spots for this equipment. However, only 1 trip with 5 Joint ACCESS ships can accomplish the transfer due to the larger payload capacity.

The 2025 Alternative Architecture I composition, as a result of downsizing to 4 MPF(F) ships, reduces the total amount of storage space available for the different

supply classes. There is virtually no affect on the total storage amounts of bottled water, provisions, and ammunition, but there is a reduction in Sea Base fuel capacity from approximately 15 million to 6.5 million gallons. This requires resupplying the Sea Base with fuel at more frequent intervals than the 2015 BLA. The Sea Base fuel resupply occurs an average of 7 times versus 4 times in the 2015 BLA.

12.7 2025 Alternative Architecture II

The 2025 Alternative Architecture II design utilizes the Rapid Strategic Lift Ship (RSLS)[269] and Landing Craft Utility, Replacement (LCU(R)) as the primary materiel solution design for changes to the 2015 BLA. Additionally, the 2025 Alternative Architecture II incorporates a different mix of aircraft from the 2015 BLA that includes more CH-53Xs and less MV-22s.

The RSLS, shown in Figure 12-9, is a conceptual family of ships, which provides a potential answer to the problem of transporting non-self-deploying aircraft such as the CH-53X, from CONUS or an Advance Base to the FLS by eliminating the reliance on strategic air lift. For the 2025 Alternative Architecture II, the RSLS transports the CH-53X, AH-1Z, SH-60R, and MV-22 air assets from the Advance Base (Okinawa) to the FLS. RSLS primary attributes include:

- a stern ramp for the RO/RO loading and unloading of cargo and helos;
- projected cruising range of 8,000 NM;
- 36 kts cruise speed;
- payload capacity of 3,000 tons;
- accommodations for 1,000-3,000 personnel; and
- 175,000 sq ft of cargo space.

[269] Jonathan Kaskin, Director Strategic Mobility/Combat Logistics Division/N42, "Rapid Strategic Lift Ship (RSLS)" (family of ships) brief, 08 March 2004.

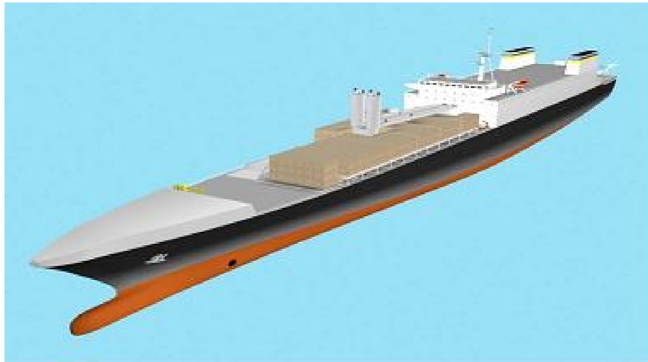


Figure 12-9: Rapid Strategic Lift Ship (RSLS).[270]

Table 12-9 summarizes Design Team II's Alternative Architecture, which evaluates the capabilities of the RSLS during each phase of Sea Base operations along with the individual platform roles and changes to the 2015 BLA.

Platform	Number	Joint Expeditionary Logistics Operations (JELo) Phase	Changes from 2015 BLA
RSLS	1	Closure/Sustainment	Addition
MPF(F) Vessels	8	All	None
LCU(R)	16	Assault	Addition of 14; replaces LCACs
MV-22	15	Assault/Sustainment	Eliminated 33 MV-22s
CH-53X	35	Assault/Sustainment	Added 15 CH-53Xs
SH-60R	12	Sustainment	None
AH-1Z	18	Sea Strike	None
F-35 JSF	36	Sea Strike	None
V-TUAV	6	Sea Strike	None
T-AOE	0	Sustainment (FLS to Sea Base)	Eliminated
LCAC	0	Assault	Eliminated
UH-1Y	0	MEDEVAC	Eliminated

Table 12-9: 2025 Alternative Architecture II Composition.

12.7.1 2025 Alternative Architecture II Nonmateriel Design Changes

Table 12-10 describes the nonmateriel changes made to the 2025 Alternative Architecture II compared to the 2015 BLA.

[270] Steven Wynn, Jeff Hough, and Howard Fireman, "Rapid Strategic Lift Ship: Feasibility Study Report," (Washington Navy Yard, DC: Naval Sea System Command, Ser 05D/097, 29 September 2004), p. 7.

2025 Alternative Architecture II Nonmateriel Changes	
Doctrine	1) Load non-self-deploying aircraft (CH-53X, SH-60R, AH-1Z) and MV-22s directly onto the RSLS at the Advance Base (no CH-53X disassembly/assembly) for transport to the Sea Base for rendezvous with the MPF(F). a. In the baseline model, the aircraft were disassembled at the Advance Base, loaded onto the C-5s and C-17s, then transported to the FLS where they were reassembled and then flown onto the MPF(F). This created a delay of 3+ days, which contributes to the closure gap in the 2015 BLA. b. This change addresses the Closure Phase gaps. 2) Use only MV-22s for MEDEVAC: a. In the 2015 BLA, all aircraft are used for MEDEVAC, with the UH-1Y designated as the primary MEDEVAC aircraft. b. The UH-1Y does not have the range and speed to meet the established requirement, which results in the change. The MV-22 has a longer range and greater speed than the UH-1Y. In addition, the MV-22 can also transport more litters and injured patients than the UH-1Y. Since the MV-22 fills a supply transport role during the Sustainment Phase, it can divert quickly to a MEDEVAC mission prior to returning to the Sea Base.
Organization	None
Training	None
Leadership	None
Personnel	None
Facilities	Forward deployment of the RSLS at the Advance Base.

Table 12-10: 2025 Alternative Architecture II Nonmateriel Changes.

12.7.2 2025 Alternative Architecture II Materiel Design Changes

The first part of the Closure Phase is the movement of assets from the Advance Base, defined as Okinawa in the Burma Scenario, to the FLS. For 2025 Alternative Architecture II, the RSLS transports the CH-53X, MV-22, AH-1Z, and SH-60R air assets from the Advance Base to the Sea Base to rendezvous with the MPF(F). The Naval Sea Systems Command (NAVSEA) RSLS Feasibility Study[271] provides data on two RSLS variants. The first variant has a flight deck, hanger, and aircraft elevator. The second variant is similar in size, but does not have the flight deck or aircraft elevator. For 2025 Alternative Architecture II, Design Team II evaluates the flight deck variant. Table 12-11 displays the characteristics of the flight deck RSLS variant as described by the NAVSEA study.[272]

[271] Ibid.
[272] Ibid., p. 6.

RSLS Characteristic	Specification
Aircraft Stowage Capacity	(35) CH-53X (15) MV-22 (12) SH-60R (18) AH-1Z
Container Cargo Weight	3 000+ short tons
Container Capacity	250+ TEUs
Total Cargo Deadweight	5 000+ short tons
Crew	40 (MSC civilians)
Passenger Capacity	1,650
Crew Sustainment Capacity	30 days
Passenger Sustainment Capacity	20 days
Stern Ramp	RO/RO for vehicles and cargo
RO/RO Ramp Capacity	35 metric tons
Survivability	No signature reduction. Only light force protection/antiterrorism weapons. Designed to commercial standards.
Navigation System	Commercial navigation and electronic systems
C4I	Commercial with military GPS

Table 12-11: RSLS Characteristics.

RSLS was chosen as the primary focal point for the 2025 Alternative Architecture II design to address the issue of transporting non-self-deploying aircraft that require time consuming disassembly and reassembly, specifically the CH-53X.

In the second part of the Closure Phase, FLS to the Sea Base, the 2025 Alternative Architecture II requires eight MPF(F) ships for use as the primary transport for the 2025 JEB forces and equipment to the Sea Base.

In the Employment Phase, the LCU(R), shown in Figure 12-10, replaces the LCAC as the primary surface transport of equipment to the beach. This change occurs to address the 20-hr employment gap from the 2015 BLA. In 2025 Alternative Architecture II, troop transport to the beach occurs via LCU(R) and Expeditionary Fighting Vehicle (EFV) to the beach.

Figure 12-10: Landing Craft Utility, Replacement (LCU(R)).[273]

Additionally, the 2025 Alternative Architecture II uses 15 MV-22s (33 less than the 2015 BLA) and 35 CH-53Xs (15 more than the 2015 BLA) for the Employment and Sustainment phases to conduct JEB replenishment at the objective. The number of aircraft changes because the CH-53X has approximately three times the payload capacity and twice the range as the MV-22.

In the Sustainment Phase, the RSLS replaces the T-AOE as the CLF ship for Sea Base resupply. With a larger cargo capacity and faster speed than the T-AOE, the RSLS is capable of providing the transport of necessary supplies from the FLS to the Sea Base. The RSLS also has the capability to include a fuel cargo configuration that provides the necessary fuel requirement that the T-AOE offers the 2015 BLA. To replenish the Sea Base, the RSLS is equipped with standard STREAM equipment. As in the 2015 BLA, the MV-22 and CH-53X vertically replenish the personnel at the objective. However, the 2025 Alternative Architecture II contains more CH-53Xs and less MV-22s.

12.8 2025 Alternative Architecture II Concept of Operations

Utilizing the 2025 Alternative Architecture II composition to generate an operational view, the following Concept of Operation emerges. Figure 12-11 depicts the JELo Operational Concept Graphic (OV-1). The Advance Base (Okinawa), not shown in

[273] Ken Maloney, "LCU(R) Landing Craft," [database online] ([cited 19 November 2004]); available from World Wide Web @ http:// www.systems.textron.com/pdf/products/lcur_datasheet.pdf.

Figure 12-11, is the initial starting point of operations. From the Advance Base, the RSLS departs with the non-self-deploying and MV-22 aircraft for direct transit to the Sea Base. Additionally, JEB personnel depart for transit from the Advance Base to the FLS. The FLS, shown in the distance, represents the starting point for the MPG. The MPG is depicted as 8 MPF(F) ships, which carry the JEB personnel and equipment from the FLS to the Sea Base; the RSLS, which also serves as a CLF ship to resupply the Sea Base; and 16 LCU(R)s, which perform the employment of the 2 surface BLTs to the beach. The aircraft represent the connectors that provide vertical BLT insertion and logistical support between the Sea Base and the objective. The lightening bolts represent the C2 system linking all assets together. The single CSG/ESG represents the inclusion of CSGs and ESGs in the Sea Base.

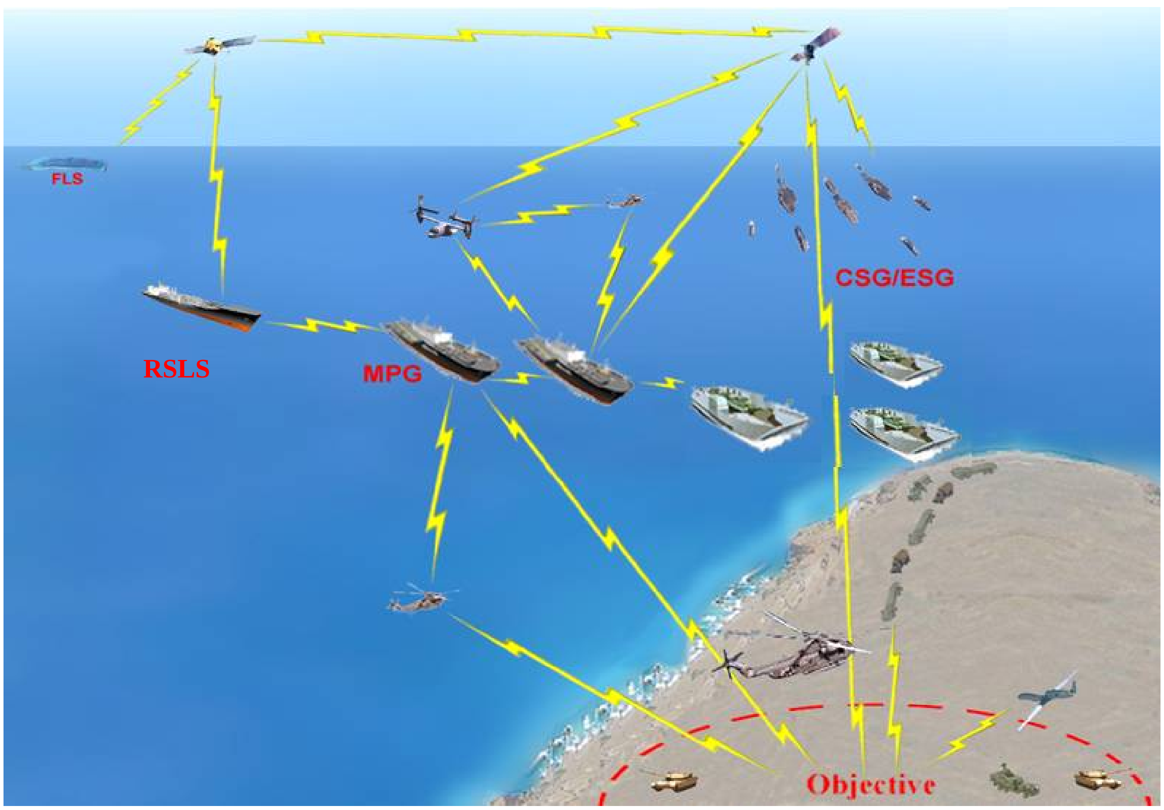


Figure 12-11: 2025 Alternative Architecture II Operational View (OV-1).

12.8.1 Closure Phase

The Closure Phase consists of the deployment, transit, assembly of personnel and equipment, and the Sea Base Formation. Closure begins with the movement of personnel

and JSFs to the FLS and the RSLS transit to the Sea Base. The MPF(F) ships and LCU(R) are assumed to be prepositioned at the FLS. The RSLS is assumed to be forward deployed at the Forward Base (Okinawa).

For personnel movement, 2025 Alternative Architecture II relies on the Civil Reserve Air Fleet (CRAF) to transport the JEB personnel from point of origin to the designated FLS. As personnel arrive at the FLS, they embark the MPF(F) pier side. The MPF(F)s perform a rotation from the FLS anchorage to the pier for personnel embarkation. The same assumptions for the 2015 BLA apply to the 2025 Alternative Architecture II.

For aircraft movement, the RSLS loads all non-self-deploying aircraft at the Advance Base (Okinawa) with the exception of the JSF aircraft. The JSFs self-deploy and can fly directly to the FLS or meet the MPF(F) ships while en route to the Sea Base. Once loaded, the RSLS departs for direct transit to the Sea Base to rendezvous with the MPF(F)s. Figure 12-12 indicates the required travel distance and time of the RSLS transit from the Advance Base (Okinawa) to the Sea Base. Since the aircraft transported via the RSLS do not require disassembly, a savings of three days is realized over the 2015 BLA. Additionally, another savings of four days occurs since the need for reassembly and functional check flights for the aircraft is eliminated at the FLS.

From	To	Distance	Time
DNA (26°21'20"N 127°46'03"E)	SIN (01°21'21"N 103°59'15"E)	2030 nm	56:23
SIN (01°21'21"N 103°59'15"E)	HKT (08°06'48"N 98°19'01"E)	527 nm	14:39
HKT (08°06'48"N 98°19'01"E)	RGN (16°54'26"N 96°08'00"E)	541 nm	15:01
Total:		3098 nm	86:03

Figure 12-12: RSLS Transit from Advance Base (Okinawa) to Sea Base.

For assembly at the Sea Base, the actions occur similarly as in the 2015 BLA. For loading purposes, the LCU(R)s become the primary surface assault equipment transport.

For the Sea Base formation, the MPF(F) ship movement of equipment and personnel from the FLS to the Sea Base is similar to the steps taken for the 2015 BLA. Once the RSLS rendezvous with the MPF(F), aircraft redistribution occurs in the same manner as the 2015 BLA.

12.8.2 Employment Phase

The manner of movement for the vertical BLT from the Sea Base to the Objective is similar to the 2015 BLA. For the employment of the 2 surface BLTs, operations begin 25 NM from the beach. LCU(R)s and EFVs deliver the personnel and equipment from

the Sea Base to the beach. The 16 LCU(R)s require approximately 60 trips to complete the employment of the 2 surface BLTs.

12.8.3 Sustainment Phase

Objective resupply occurs in the same manner as the 2015 BLA, with the exception of the number of MV-22 and CH-53X connectors.

The RSLS replaces the T-AOE as the CLF ship for resupply of the Sea Base. The RSLS, once it offloads aircraft at the Sea Base, assumes the resupply for operations between the FLS and the Sea Base. At the Sea Base, the MPF(F)s are resupplied via connected and vertical replenishment.

12.8.4 Medical Evacuation

The MV-22 is the sole asset used to conduct the MEDEVAC mission. In addition to delivering supplies to the objective, the MV-22, after delivery of its cargo, checks for casualties prior to returning to the Sea Base.

12.8.5 Cost Estimation of 2025 Alternative Architecture II

Table 12-12 is a cost estimate summary for the 2025 Alternative Architecture II. The cost estimate contains acquisition cost data and ten years of operating and support (O & S) cost data. Calculations to determine the cost estimate are similar to those from Chapter 7, Baseline Architecture Cost Estimation Analysis. Example cost estimate calculations are in Appendix C. Cost data is normalized using the inflation indices provided by the Naval Cost Analysis Division (NCAD) to account for inflation and the time value of money[274] and is provided in FY04$.

[274] Inflation indices are from the Navy Cost Analysis Division (NCAD) and are located at http://www.ncca.navy.mil/services/inflation.cfm.

Platform	Quantity	Acquisition Cost (FY04$)	10 Years of O&S Costs (FY04$)	Total Cost (FY04$)
MPF(F)	8	$13,686,187,886	$4,504,749,160	$18,190,937,046
RSLS	1	$1,332,654,959	$363,824,743	$1,696,479,703
MV-22	15	$1,185,105,000	$805,848,390	$1,990,953,390
CH-53X	35	$1,923,378,135	$771,320,025	$2,694,698,160
SH-60R	10	$364,761,548	$456,754,500	$821,516,048
AH-1Z	18	$362,701,736	$600,539,040	$963,240,776
JSF (F-35)	36	$2,994,231,545	$2,002,489,920	$4,996,721,465
UAV	6	$11,049,804	$77,348,820	$88,398,624
LCU(R)	16	$274,442,105	$165,254,880	$439,696,985
Total Cost		$22,134,512,717	$9,748,129,478	$31,882,642,196

Table 12-12: 2025 Alternative Architecture II Cost Estimation.

To conduct a cost estimate for the RSLS, cost data from the CNA MPF(F) study[275] for the "family, specialized constrained logistics and RO/RO ship" variant is used. This variant's cost is comparable to the cost estimate from the NAVSEA study.[276] The CNA cost data is the preferred costing source since the NAVSEA cost data is proprietary data and considered business sensitive.[277] The LCU(R) is a current funded program that has extensive cost data located in the FY05 President's Budget.[278]

12.9 2025 Alternative Architecture II Modeling Results and Evaluation

Of the eight COIs addressed, the 2025 Alternative Architecture II successfully meets the requirements of seven. The only COI that the 2025 Alternative Architecture II fails to meet is COI 5 regarding employment of the Sea Base Maneuver Element (SBME) ashore in 10 hrs. The specific answers to each COI, as evaluated from the scenario simulation, follow in the details below.

[275] Robert M. Souders, Suzanne Schulze, Yana Ginburg, and John Goetke, "MPF(F) Analysis of Alternatives: Final Summary Report," (Alexandria, VA: The CNA Corporation, CNR D0009814.A2/Final April 2004), pp. 48-54.
[276] Steven Wynn, Jeff Hough, and Howard Fireman, "Rapid Strategic Lift Ship: Feasibility Study Report," (Washington Navy Yard, DC: Naval Sea System Command, Ser 05D/097, 29 September 2004).
[277] Steven Wynn, [WynnSB@NAVSEA.NAVY.MIL], "RSLS Questions," 05 November 2004, Office Communication, (08 November 2004).
[278] Department of Defense, Defense Budget Materials: FY2005 Budget, [database online] (10 March 2004 [cited 01 November 2004]); available from World Wide Web @ http://www.dod.mil/comptroller/defbudget/fy2005/index.html.

12.9.1 Closure Phase

The Closure Phase involves the deployment, transit, assembly of personnel and aircraft, and the Sea Base formation. There are three COIs that address the Closure phase. COI 1 addresses the delivery of the SBME and the SBSE to the FLS in time to meet the 10-day requirement. COI 2 involves the loading of the SBME and the SBSE aboard the MPF(F) in time to meet the 10-day requirement. COI 3 addresses the MPF(F) vessels ability to get underway from the FLS in time to meet the 10-day requirement.

For the deployment and transit aspect of the Closure Phase, COI 1 involves the delivery of the SBME and the SBSE to the FLS in time to meet the 10-day requirement. In the 2025 Alternative Architecture II, the SBME and SBSE personnel arrive at the FLS in 121 hrs, meeting the 127-hr requirement.

COI 2 addresses the assembly requirement for the Closure Phase and involves the loading of the SBME and SBSE aboard the MPF(F) in time to meet the 10-day requirement. Analysis of the 2025 Alternative Architecture II indicates that the time to load the SBME and SBSE aboard the MPF(F) for personnel is 62 hrs, well below the 127-hr requirement.

COI 3 involves the ability of the MPF(F) vessels to get underway from the FLS in time to meet the 10-day requirement. There are no departure delays in the 2025 Alternative Architecture II. MPF(F) ships are underway in 92 hrs. This is a result of all aircraft (except the JSF) being transported onboard the RSLS and the elimination of assembly and reassembly time delays associated with the CH-53X helicopter.

12.9.2 Employment Phase

The Employment Phase involves delivering the 2 surface BLTs and 1 vertical BLT to the objective within a 10-hr period. Air assault connectors deliver 1 vertical BLT, while surface assault connectors deliver the remaining 2 surface BLTs.

COI 5 involves the employment of the SBME to an objective in a 10-hr period. In the 2015 BLA, there was a capability gap of 20 hrs. The 2025 Alternative Architecture II delivers the SBME from the Sea Base to the Objective in 12 hrs. This exceeds the 10-hr requirement, producing a 2-hr gap as shown in Figure 12-13. However, this alternative architecture produces an 18-hr capability gap reduction over the 2015 BLA. The 2-hr capability gap for the 2025 Alternative Architecture II is due to the employment of the 2 surface BLTs. To employ the 2 surface BLTs, multiple trips are required by the LCU(R)s. The time delay to load each LCU(R) via ILP at the Sea Base and the subsequent transit time contributes to the 2-hr capability gap. The employment of the vertical BLT is accomplished under the 10-hr requirement.

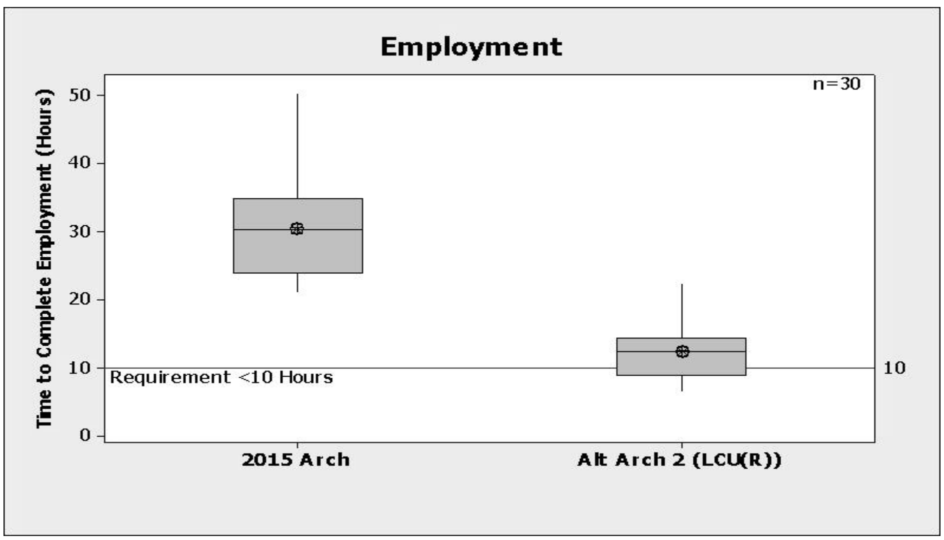


Figure 12-13: Employment of SBME at the Objective for 2025 Alternative Architecture II.

12.9.3 Seize the Initiative

In accordance with the Operating Concept [Chapter 2], the force has 10 days to seize the initiative. In order to seize the initiative, the 2025 Alternative Architecture II must complete the Closure, Assembly, and Employment Phases of operations. COI 6 provides insight into this requirement.

COI 6 involves the delivery of a JEB from the Advance Base (Okinawa) to the FLS and then to the Sea Base, to include employing 2 surface BLTs and 1 vertical BLT at the objective ashore with a goal of 10 days (240 hrs). The 2025 Alternative Architecture

II meets this requirement by delivering the combat element of the JEB to the objective in approximately 230 hrs.

12.9.4 Sustainment Phase

The Sustainment Phase involves delivering supplies from the Sea Base to the objective for a mission time of 30 days. The air assault connectors sustain the JEB at the objective. Additionally, during the 30-day mission time, a resupply ship must also sustain the Sea Base. COIs 7 and 8 provides the sustainment information needed for both Sea Base and objective to evaluate this system requirement.

COI 7 first addresses the sustainment of the Sea Base for a minimum of 30 days (720 hrs). In the 2025 Alternative Architecture II, at no point do any classes of supply reach exhaustion. With the materiel change of the RSLS in its role of performing resupply after the Employment Phase, the Sea Base is able to maintain supplies above the reserve level. There are no instances when the reserve level for supplies at the Sea Base for provisions and fuel falls below the requirement, as shown in Figures 12-14 and 12-15.

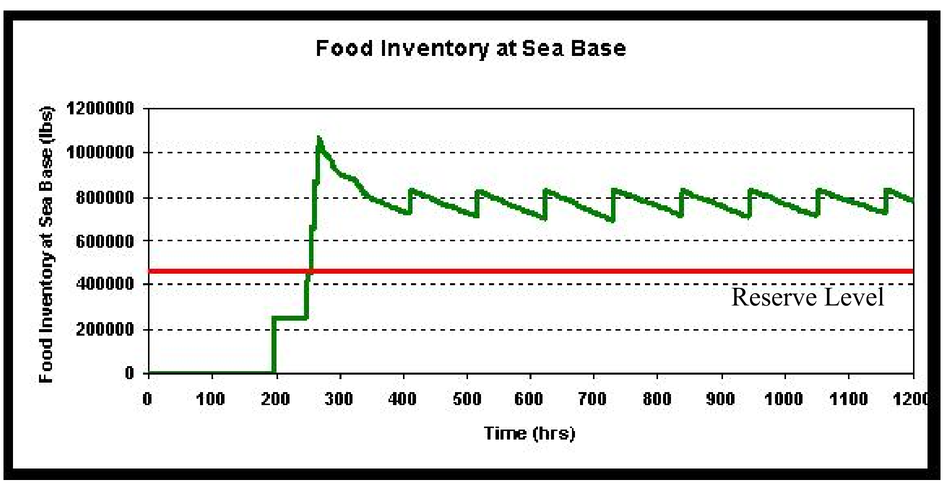


Figure 12-14: Sea Base Provisions Sustainment for the 2025 Alternative Architecture II.

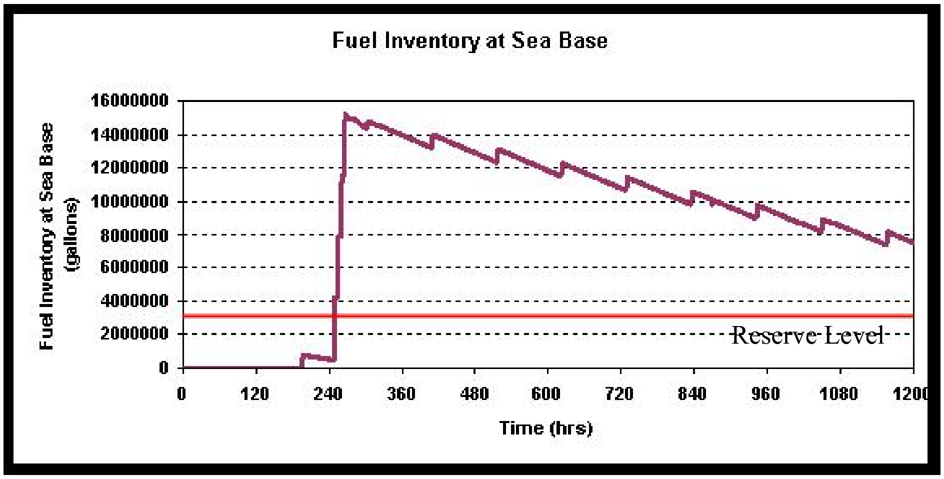


Figure 12-15: Sea Base Fuel Sustainment for the 2025 Alternative Architecture II.

COI 7 also addresses the sustainment of the objective from the Sea Base for a minimum of 30 days (720 hrs). In the 2025 Alternative Architecture II, no class of supply is ever fully exhausted or falls below the critical reserve level during the Sustainment Phase. COI 7 also permits an evaluation of the maximum distribution capacity of the SBME. Figure 12-16 indicates that during the initial start of the Sustainment Phase, an oversupply of provisions occurs. This occurs due to a model artificiality in which air connectors begin delivering supplies prior to the exhaustion of the initial supplies delivered during the Employment Phase.

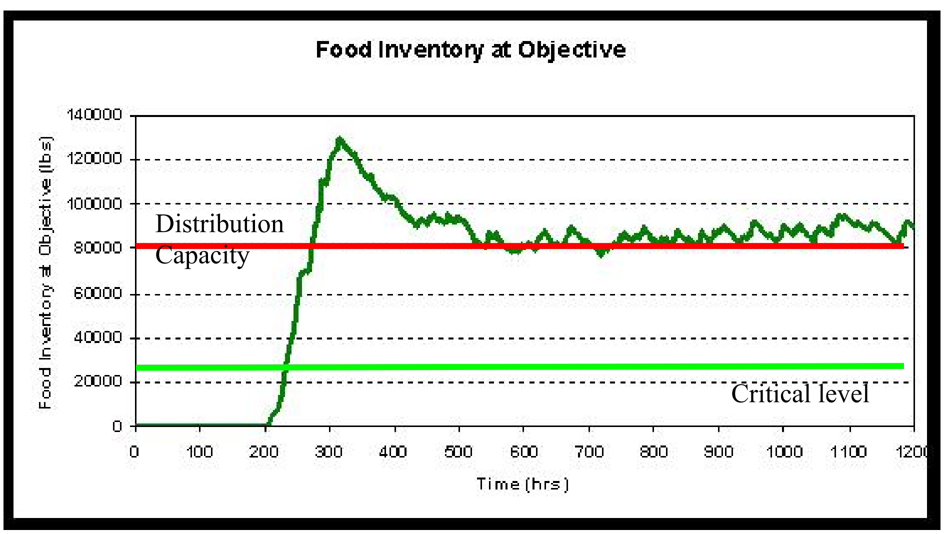


Figure 12-16: Provisions Inventory at the Objective during the Sustainment Phase for the 2025 Alternative Architecture II.

COI 8 addresses the sustainment of the objective by vertical lift only. The total range from Sea Base to objective for the scenario is 150 NM, which is just under the 165-NM maximum range of the MV-22 with external cargo loads. If the 165-NM range of the MV-22 is exceeded, the 35 CH-53Xs are not capable, themselves, of meeting the sustainment demands of the ashore forces. Sensitivity analysis reveals approximately 50 CH-53Xs would be required to sustain the objective between 165 and 200 NM.

12.9.5 Medical Evacuation

COI 9 involves the medical evacuation (MEDEVAC) of the wounded personnel within the Golden Hour (defined in Chapter 2). In 2025 Alternative Architecture II, the doctrine change from using the UH-1Y as the primary MEDEVAC platform to assigning only the MV-22 MEDEVAC results in meeting this requirement. On average, the 2025 Alternative Architecture II can perform all MEDEVAC operations from the objective to the Sea Base within 30 minutes.

12.9.6 Summary

The 2025 Alternative Architecture II utilizes a RSLS to deliver the non-self-deploying aircraft to the Sea Base. Additionally, the RSLS serves as the CLF ship during the Sustainment Phase. This eliminates the need for disassembly and reassembly of the CH-53X. Additionally, LCU(R)s replace the LCACs in the Employment Phase. The use of the HLCAC vice the LCAC was explored. However, use of HLCACs is not effective. Use of the HLCAC as the primary surface assault connector resulted in a capability gap of 18 hrs. Additionally, Design Team I moved the MPF(F) from 25 NM to 10 NM off the beach to further test the close-in effects of using the HLCAC. This closer range still resulted in a capability gap of 13 hrs and drastically increased the risk of enemy intervention.

Implementing the LCU(R) vice the LCAC or HLCAC reduces the number of trips required to employ the forces ashore. Use of the LCU(R) reduces the Employment Phase gap to only 2 hrs, an 18-hr improvement over the 2015 BLA.

Alternative Architecture II employs 33 less MV-22s and 15 more CH-53Xs for the employment of the vertical BLT and sustainment of the JEB ashore. This mix of aircraft produces favorable results for both vertical BLT employment and sustainment.

12.10 2025 Alternative Architecture II Potential New Issues Created

The use of the RSLS creates a single point of failure. Instead of having the non-self-deploying aircraft transported via multiple platforms, they are all located on a single platform. If the RSLS experiences mechanical problems or other delays, all the required assault air connectors arrive at the Sea Base late. Additionally, survivability is an issue. If the enemy realizes the RSLS is a center of gravity, there are several opportunities during the transit to the Sea Base from the Advance Base (Okinawa) for enemy intervention.

12.11 2025 Alternative Architecture III

The 2025 Alternative Architecture III utilizes airships, Advanced Theater Transports (ATT), and the MPF(F) aviation variant as the primary changes to the 2015 BLA. This alternative architecture also explores the feasibility of transporting non-self-deploying aircraft from CONUS vice an Advance Base (Okinawa) to the FLS. An MPF(F) aviation variant is a flat deck MPF(F) ship, approximately 1,000 ft long, with no island structure. This MPF(F) aviation ship is designed to operate the ATT, a C-130-type aircraft with a tilt wing design. Designs for the ATT call for an extremely short take off and landing (STOL) capability. Additionally, this alternative architecture increases the number of MV-22s and eliminates CH-53Xs.

An airship, using lighter-than-air technology, presents a solution to the movement of non-self-deploying aircraft to the FLS. Airship technology is undergoing changes with the use of modern, lightweight, high-strength materials and the use of vectored thrust. Several programs under study include the Heavy Lift Air Vehicle (Walrus) and the Hybrid Ultra Large Aircraft (HULA). Figure 12-17 is a graphic representation of this emerging technology.

Figure 12-17: Graphic Representation of Ligher-than-air Heavy Lift Airship.[279]

The proposed heavy lift airship SkyCat™ 1000[280] is a representative of the lighter-than-air technology for use in the 2025 Alternative Architecture III. SEA-6 makes no claims that this is the best airship or that this particular airship is the optimal platform, only that it is representative of airships in general. The SkyCat™ 1000 transports non-self-deploying aircraft and MV-22s from CONUS to the FLS in the 2025 Alternative Architecture III. Table 12-13 summarizes 2025 Alternative Architecture III's design.

[279]Globalsecurity.org, "SkyCat 1000," [database online] (30 September 2004 [cited 17 November 2004]) available from World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/skycat.htm.
[280] Advanced Technologies Group, "SkyCat Hybid Air Vehicle, United Kingdom" [database online] (22 March 2004 [cited 22 October 2004]) available from World Wide Web @ http://www.aerospace-technology.com/projects/skycat/).

Platform	Number	Joint Expeditionary Logistics (JELo) Phase	Change from 2015 BLA
MPF(F) Unconstrained-size, distributed-capability ships[281]	4	Closure/Employment/Sustainment	Eliminated 4 ships; change to add an additional ILP to each ship
MPF(F) Aviation ship[282]	1	Closure/Employment/Sustainment	Addition
T-AOE	1	Sustainment	None
MV-22	65	Employment/Sustainment	Addition of 17 MV-22s
ATT	8	Employment/Sustainment	Addition of 8 ATTs
SH-60R	10	Sustainment	None
AH-1Z	18	Sea Strike	None
F-35 (JSF)	36	Sea Strike	None
VTUAV	6	Sea Strike	None
LCU(R)	12	Employment	Addition of 10
SkyCat™ 1000	6	Closure/Sustainment	Addition
LCAC	0	Employment	Eliminated
UH-1Y	0	MEDEVAC	Eliminated
CH-53X	0	Employment/Sustainment	Eliminated

Table 12-13: 2025 Alternative Architecture III Composition.

12.11.1 2025 Alternative Architecture III Nonmateriel Design Changes

Table 12-14 describes the nonmateriel changes made to Alternative Architecture III from the 2015 BLA.

Alternative Architecture III Nonmateriel Changes	
Doctrine	1) Non-self-deploying aircraft and MV-22s transported from CONUS to the FLS by loading the aircraft onto the SkyCat™ 1000. a) In the 2015 BLA, the MV-22s self-deploy to the FLS and the CH-53Xs are disassembled and transported to the FLS, assembled and then flown to the MPF(F), creating a time delay of 3+ days. b) SkyCat™ 1000 addresses the CH-53X time delay. 2) Use MV-22s and ATTs for MEDEVAC a) In the 2015 BLA, the UH-1Y is designated as the primary MEDEVAC aircraft. The UH-1Y does not have the range and speed to meet the SEA 6 established requirement. The MV-22 has a longer range and greater speed than the UH-1Y. In addition, the MV-22 can also transport more litters and injured patients than the UH-1Y. Since the MV-22 is a supply transport during the Sustainment Phase, it can divert quickly to a MEDEVAC mission prior to returning to the Sea Base. b) ATT supplements the MV-22 and can carry 96 litters. c) This change addresses the MEDEVAC gap.
Organization	None
Training	None
Leadership	None
Personnel	None
Facilities	None

Table 12-14: 2025 Alternative Architecture III Nonmateriel Changes.

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[281] Robert M. Souders, Suzanne Schulze, Yana Ginburg, and John Goetke, "MPF(F) Analysis of Alternatives: Final Summary Report," (Alexandria, VA: The CNA Corporation, CNR D0009814.A2/Final, April 2004), p. 33.
[282] Ibid., p. 46.

12.11.2 2025 Alternative Architecture III Materiel Design Changes

For the Closure Phase, Design Team III uses six airships for the transportation of non-self-deploying aircraft to the FLS to address the 2015 BLA capability gaps. CRAF aircraft provide transportation for personnel by the same means detailed in the 2015 BLA [Chapter 5].

The SkyCat™ 1000 vehicle combines lighter-than-air airship technology and air-cushioned hovercraft technology, allowing landings on flat land, grass, swamp, water (including the open ocean), and snow.[283] Utilizing reverse thrust on the hovercraft engines (suck-down mode) will allow it to remain stationary.[284] The airship has a projected cruising range of 6,000+ NM empty and can carry a maximum payload of 1,100 tons.[285] A reduced payload of 750 tons allows for a range of 5,500+ NM.[286] Each airship is capable of transporting the weight of 66 MV-22 aircraft; however, cargo area limits this to 13 MV-22s—approximately 20% of the airship's weight-carrying capacity. This decreased payload permits the SkyCat™ 1000 to operate with the 5,500 NM endurance range. The airship also resupplies provisions, bottled water, and ammunition to the Sea Base from the FLS. Figure 12-18 shows a SkyCat™ demonstration model.

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[283] Advanced Technologies Group, "SkyCat Hybid Air Vehicle, United Kingdom," [database online] (22 March 2004 [cited 22 October 2004]) available from World Wide Web @ http://www.aerospace-technology.com/projects/skycat/).
[284] Paul Macey, [P.Macey@ConnectFree.co.uk], "SkyCat," 28 October 2004, Office Communication, (29 October 2004).
[285] Ibid.
[286] Ibid.

Figure 12-18: SkyCat™ 1000 Demonstration Model.[287]

In the Closure Phase, eight ATTs self-deploy to the FLS from CONUS. The ATT, shown in Figure 12-19, is a C-130 type airframe with a four turbo prop engine/ tilt wing design. ATTs have an extreme STOL capability and can land at unprepared landing sites. The ATT has a cruising speed of 300 kts, a range of 2,100 NM, and a fuel capacity of 60,000 lbs.[288]

Figure 12-19: Advance Theater Transport.[289]

In 2025 Alternative Architecture III, the number of MPF(F) ships is reduced from 8 to 5. The new MPG configuration consists of 4 unconstrained-size, distributed

[287] Ibid.
[288] Globalsecurity.org, "Advanced Theater Transport," [database online] (01 December 2002 [cited 23 November 2004]) available from World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/att.htm.
[289] Globalsecurity.org, "Advanced Theater Transport," [database online] (01 December 2002 [cited 16 November 2004]) available from World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/att-pics.htm, (16 November 2004).

capability variants and 1 modified aviation variant, shown in Figure 12-20. The MPF(F) load-out plan for the 2025 Alternative Architecture III is shown in Table 12-15.

Load	MPF(F) 1 (lbs)	MPF(F) 2 (lbs)	MPF(F) 3 (lbs)	MPF(F) 4 (lbs)	MPF(F) 5 Aviation (lbs)	Total (lbs)
Food	104,394	104,394	104,394	104,394	104,394	521,970
Fuel	1,848,000	1,848,000	1,848,000	1,848,000	1,848,000	9,240,000
Water	127,549	127,549	127,549	127,549	127,549	637,745
Ammo	1,687,500	1,687,500	1,687,500	1,687,500	1,687,500	8,437,500
LCAC	0	0	0	0	0	0
ATT	0	0	0	0	8	8
MV-22	16	16	16	17	0	65
LCU(R)	3	3	3	3	0	12
AH-1Z	5	5	4	4	0	18
Troops	1,620	1,620	1,620	1,620	1,620	8,100
M1A1	7	7	7	7	0	28
EFV	27	27	26	26	0	106
ABV	1	1	1	1	0	4
AVLB	1	1	1	1	0	4
M88A2	1	1	1	1	0	4
M9 ACE	2	2	2	2	0	8
HMMWV	81	81	81	81	101	425
ITV	4	4	4	4	0	16
LAV	14	14	14	14	28	84
MTVR	22	22	23	23	0	90
4K Forklift	2	2	2	2	0	8
Contact Truck	4	4	5	5	0	18
EFSS	0	0	0	0	8	8
HIMARS	7	7	8	8	0	30
LVS	9	9	9	9	0	36

Table 12-15: 2025 Alternative Architecture III MPF(F) Load-out Distribution.

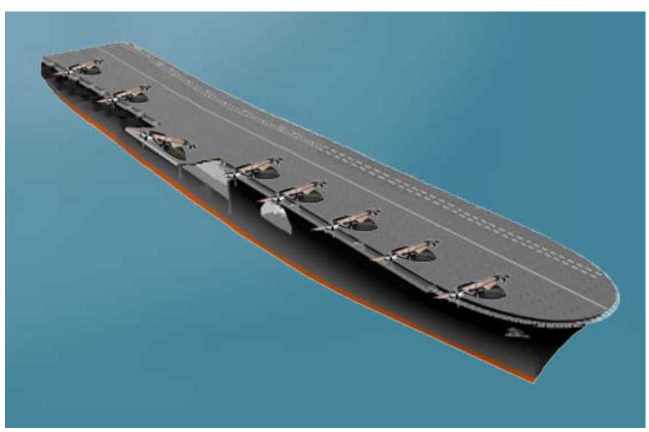

Figure 12-20: 2025 Alternative Architecture III MPF(F) Aviation Variant.

In the Employment Phase, Design Team III uses the LCU(R) and the ATT to address the 20-hr Employment Phase gap from the 2015 BLA. Twelve LCU(R)s replace the 24 LCACs and 8 ATTs replace the 20 CH-53Xs from the 2015 BLA. The LCU(R) has a cargo area of approximately 2,800 sq ft and a payload capacity of 495,000 lbs. This translates into a 55% increase in cargo area and a 313% increase in payload capacity over the LCAC. Additionally, the LCU(R) can carry 3 M1A1 tanks and has a full payload speed of 30 kts. The ATT can carry an internal cargo load of 60,000 lbs, while still maintaining STOL capability and has a cargo area of approximately 500 sq ft. This translates to an approximate 122% increase in cargo area and a 100% increase in payload capacity over the CH-53X.

For the Sustainment Phase, Design Team III uses 65 MV-22s and 8 ATTs to conduct all sustainment operations for the JEB at the objective. The 2015 BLA details the capacities and characteristics of the MV-22 aircraft.

For Sea Base resupply, Design Team III uses the SkyCat™ 1000 to augment the T-AOE. The limited storage capacity of 5 vice 8 MPF(F) ships results in an additional resupply requirement. Using the SkyCat™ 1000 to augment the T-AOE in the Sustainment Phase meets the Sea Base resupply needs. Since no current literature supports the use of an airship to transport fuel, Design Team III did not examine the possibility of the SkyCat™ 1000 replacing the T-AOE completely.

12.12 2025 Alternative Architecture III Concept of Operations

Utilizing the 2025 Alternative Architecture III composition to generate an operational view, the following Concept of Operations emerges. Figure 12-21 depicts the JELo Operational Concept Graphic (OV-1). CONUS (not shown) in Figure 12-21, is the initial starting point of the operation for this alternative architecture. From CONUS, the SkyCat™ 1000 transports non-self-deploying aircraft and MV-22s to the FLS. The FLS shown in the distance represents the starting point for the MPG. The MPG is depicted as MPF(F) ships, which carry the JEB personnel and equipment from the FLS to the Sea Base; a T-AOE which resupplies the MPF(F) ships with fuel; and LCU(R) vessels

which deliver the two surface BLTs to the beach. The SkyCat™ 1000 also serves as a high-speed resupply asset for provisions and ammunition to the Sea Base. The ATT and other aircraft represent the connectors that provided vertical BLT insertion and logistical support between the MPG and objective. The lightening bolts represent the C2 system linking all assets together. The single CSG/ESG represents the inclusion of CSGs and ESGs in the Sea Base.

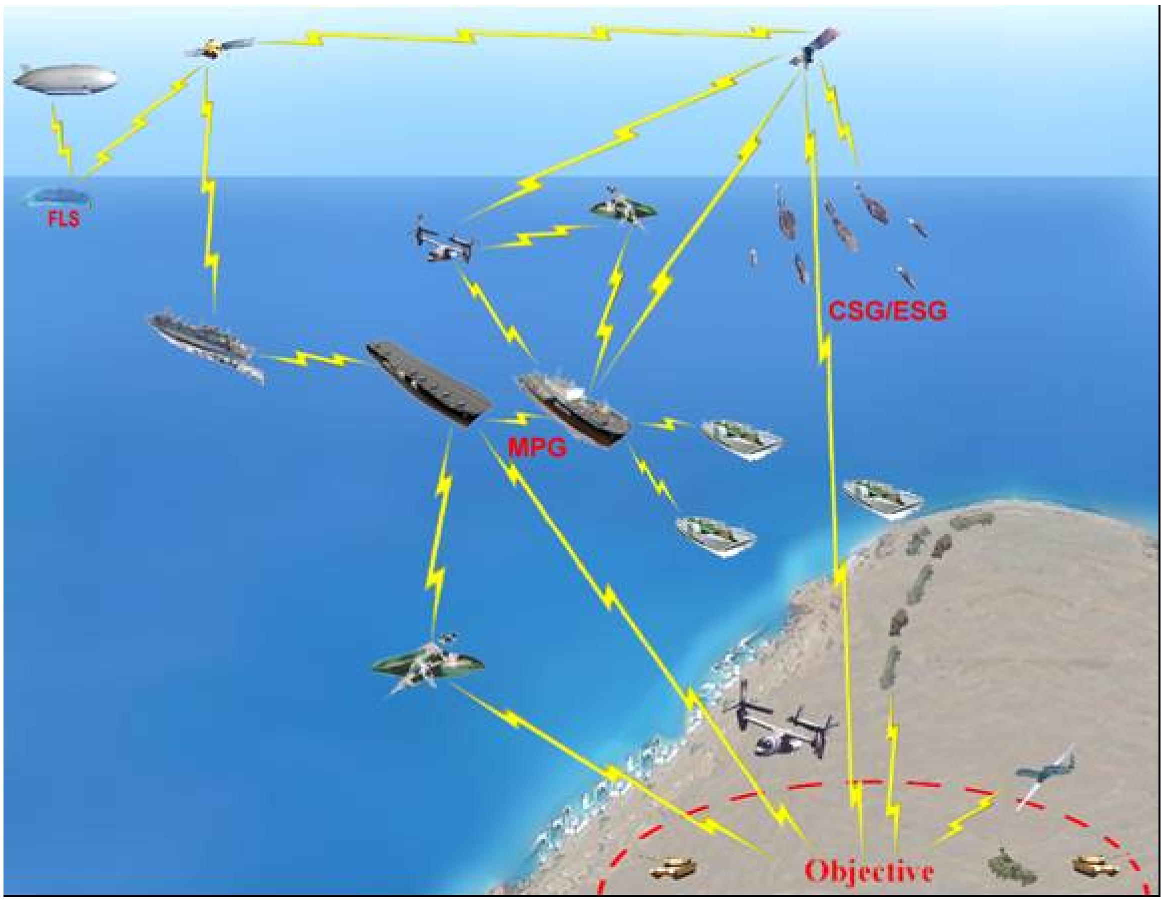

Figure 12-21: Alternative Architecture III Operational View (OV-1).

12.12.1 Closure Phase

The Closure Phase consists of the deployment, transit, assembly of personnel and equipment, and the Sea Base formation. Closure begins with the movement of personnel and aircraft to the FLS. The starting point is CONUS vice an Advance Base (Okinawa). The 12 LCU(R)s are assumed to be forward deployed at the FLS.

For personnel movement, the 2025 Alternative Architecture III relies on the CRAF to transport the JEB from point of origin to the designated FLS. The same assumptions for the 2015 BLA apply to the 2025 Alternative Architecture III.

For aircraft movement, non-self-deploying aircraft and MV-22s fly to CONUS SkyCat^{TM} 1000 locations to load onto six airships for transport to the FLS. The ATTs will self-deploy to the FLS similar to the JSFs as outlined in Chapter 5.

The starting point time and distance calculations for movement of the aircraft are based on a SkyCat^{TM} 1000 speed of advance (SOA) of 100 kts from CONUS to the FLS as shown in Figure 12-22. These calculations result in a transit time of approximately four days with the addition of stops for refueling. The SkyCat^{TM}1000 experiences no crew rest delays and does not require the use of in-flight refueling assets.

From	To	Distance	Time
SAN (32°44'01"N 117°11'23"W)	MUE (20°00'05"N 155°40'05"W)	2195 nm	21:57
MUE (20°00'05"N 155°40'05"W)	GUM (13°29'00"N 144°47'46"E)	3433 nm	34:20
GUM (13°29'00"N 144°47'46"E)	SIN (01°21'21"N 103°59'15"E)	2533 nm	25:20
SIN (01°21'21"N 103°59'15"E)	NKW (07°18'48"S 72°24'40"E)	1963 nm	19:38
Total:		10124 nm	101:14

Code	Source	Location
GUM	FAA	Agana [Guam Intl], GU, US
MUE	FAA	Kamuela [Waimea-Kohala Airport], HI, US
NKW	DAFIF	Diego Garcia, IO
SAN	FAA	San Diego [Intl], CA, US
SIN	DAFIF	Singapore [Changi Intl Airport], SG

Figure 12-22: SkyCat^{TM} 1000 Transit from CONUS to FLS.

The movement of the MPF(F) ships from the FLS to the Sea Base is accomplished as in the 2015 BLA. The 5 MPF(F) ships will transit with and support the 12 LCU(R)s to the Sea Base. Aircraft redistribution occurs in the same manner as the 2015 BLA.

For assembly at the Sea Base, the actions occur similarly as in the 2015 BLA. For loading purposes, the LCU(R)s become the primary surface assault equipment transport.

12.12.2 Employment Phase

Equipment and troop movement is similar to the 2015 BLA. The main difference from the 2015 BLA is the utilization of 12 LCU(R)s and 8 ATTs. The LCU(R)s will be operated in the same manner as the 2015 BLA except that 2 LCU(R)s are loaded simultaneously from each of the 4 2015 BLA MPF(F) ships. Each MPF(F) ship has 2 ILPs positioned on the same side of the ship, 1 forward and 1 aft.

The ATT replaces the CH-53X and operates exclusively from the aviation-type MPF(F) ship. ATTs launch fully loaded to the objective where one of two cargo delivery methods is used. The first method is for the ATT to utilize extremely short field landing capabilities to land at an unprepared landing site where supplies are off-loaded. The second method is to employ a Low Altitude Parachute Extraction System (LAPES) as shown in Figure 12-23. LAPES is a low-level, self-contained system capable of delivering heavy loads into an area where air landing is not feasible.[290]

[290] Defense Technical Information Center, "LAPES" [database online] (01 October 2004 [cited 09 December 2004]) available from World Wide Web @ http://www.dtic.mil/doctrine/jel/doddict/data/l/03127.html.

Figure 12-23: C-130 Employing LAPES.[291]

12.12.3 Sustainment Phase

Sustainment of the forces at the objective is similar to the 2015 BLA. Eight ATTs replace all the CH-53Xs and 18 additional MV-22s are added to meet the vertical lift needs of the Sea Base.

The Sea Base is resupplied using the T-AOE capabilities described in the 2015 BLA. One SkyCat™ 1000 augments the T-AOE to meet the Sea Base resupply. The re-supply of the Sea Base is accomplished by the airship landing on the MPF(F) aviation ship, where it will off-load provisions and ammunition. Figure 12-24 depicts an example of this concept. This photograph, taken on June 26, 1950, shows the ZP2K-80 (blimp), piloted by Lt. John Fahey, taking off from the U.S.S. Midway (CV-41) after a demonstration of an airship landing for the Chief of Naval Operations and the Commander in Chief, U.S. Atlantic Fleet, who were aboard Midway. Design Team III did not explore the possibility of all six airships replacing the T-AOE as the primary resupply source for the Sea Base due to fuel cargo issues with airships.

[291] Globalsecurity.org, “C-130 Hercules” [database online] (12 October 2004 [cited 17 November 2004]) available from World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/c-130-pics.htm.

Figure 12-24: Demonstration of an Airship Carrier Landing.[292]

12.12.4 Medical Evacuation

In the 2025 Alternative Architecture III, the MV-22 and the ATT conduct the MEDEVAC mission. In addition to delivering supplies to the objective, MV-22s and ATTs, after delivery of their shipment, check for casualties prior to returning to the Sea Base.

12.12.5 Cost Estimation of 2025 Alternative Architecture III

Table 12-16 is a cost estimate summary for the 2025 Alternative Architecture III. The cost estimate contains acquisition cost data and 10 years of operating and support (O & S) cost data. Calculations to determine the cost estimate are similar to those from Chapter 7, Baseline Architecture Cost Estimation Analysis. Example cost estimate calculations are in Appendix C. Cost data is normalized using the inflation indices provided by the Naval Cost Analysis Division (NCAD) to account for inflation and the time value of money[293] and is provided in FY04$.

[292] Unknown, "Naval Airship Carrier Operations," [database online] (25 May 2001 [cited 23 November 2004]) available from World Wide Web @ http://www.naval-airships.org/carrier.html.
[293] Inflation indices are from the Navy Cost Analysis Division (NCAD) and are located at http://www.ncca.navy.mil/services/inflation.cfm.

Platform	Quantity	Acquisition Cost (FY04$)	10 Years of O&S Costs (FY04$)	Total Cost (FY04$)
MPF(F) - Baseline variant	4	$7,293,655,715	$2,252,374,580	$9,546,030,295
MPF(F) - Aviation/C2 variant	1	$1,828,684,151	$440,332,519	$2,269,016,670
T-AOE	1	$739,106,413	$868,543,070	$1,607,649,483
MV-22	65	$5,135,455,000	$3,492,009,690	$8,627,464,690
SkyCat 1000	6	$1,200,000,000	$34,985,313	$1,234,985,313
ATT	8	$932,132,706	$59,475,033	$991,607,739
SH-60R	12	$437,713,857	$548,105,400	$985,819,257
AH-1Z	18	$362,701,736	$600,539,040	$963,240,776
JSF (F-35)	36	$2,994,231,545	$2,002,489,920	$4,996,721,465
UAV	6	$11,049,804	$77,348,820	$88,398,624
LCU(R)	12	$205,831,579	$123,941,160	$329,772,739
Total Cost		$21,140,562,506	$10,500,144,545	$31,640,707,052

Table 12-16: 2025 Alternative Architecture III Cost Estimation.

Cost data for the modified aviation/C2 MPF(F) variant is from the CNA MPF(F) study.[294] This modified variant has a different flight deck than the one proposed by CNA. A cost factor based on the CNA reported cost increase for major reconfigurations is used to estimate the cost of this MPF(F) variant. The SkyCat™ 1000 is a lighter-than-air technology that is being explored by the Department of Defense.[295] Acquisition costing data is from one of the current designers.[296] Since no current system resembles the ATT, the O & S cost data for the C-130 is the analogous system used to develop future O & S costs on the basis that the ATT will serve as a transport craft. The ATT is a potential future replacement for the current C-130 transport aircraft.[297] Since it is a potential replacement for the C-130, the C-130 costing data is used to develop the ATT cost. A cost factor based on the potential cargo payload is used to calculate the acquisition and O & S costs for the ATT.

[294] Souders et al., pp. 48-54.
[295] GlobalSecurity.org, "SkyCat 1000," [data online] (30 September 2004 [cited 03 November 2004]); available from World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/skycat.htm.
[296] Paul Macey, [P.Macey@ConnectFree.co.uk], "SkyCat," 28 October 2004, Office Communication, (29 October 2004).
[297] Military Analysis Network, "Advanced Theater Transport," [data online] (02 January 1999 [cited 03 November 2004]); available from World Wide Web @ http://www.fas.org/man/dod-101/sys/ac/att.htm.

12.13 2025 Alternative Architecture III Modeling Results and Evaluation

2025 Alternative Architecture III successfully meets the requirements of the eight COIs addressed. The specific answers to each COI, as evaluated from the scenario simulation, follow in the details below.

12.13.1 Closure Phase

The Closure Phase involves the deployment, transit, assembly of personnel and aircraft, and the Sea Base formation. There are three COIs that address the Closure Phase. COI 1 addresses the delivery of the SBME and the SBSE to the FLS in time to meet the 10-day requirement. COI 2 involves the loading of the SBME and the SBSE aboard the MPF(F) in time to meet the 10-day requirement. COI 3 addresses the MPF(F) vessels' ability to get underway from the FLS in time to meet the 10-day requirement.

For the deployment and transit aspect of the Closure Phase, COI 1 involves the delivery of the SBME and the SBSE to the FLS in time to meet the 10-day requirement. Aircraft arriving at the FLS cannot exceed 55 hrs to allow loading of the MPF(F) ships so they can deploy with sufficient time to meet this COI. In the 2025 Alternative Architecture III, aircraft transported by the SkyCat™1000 arrive in 96 hrs. This creates a 41-hr gap. However, the elimination of CH-53Xs from this alternative architecture also eliminates the reassembly delay the CH-53Xs require that offsets the 41-hr gap. In order to meet the overall 10-day requirement, the MPG must deploy within 140 hrs. As shown in Figure 12-25, the MPG is able to deploy within the 140-hr requirement.

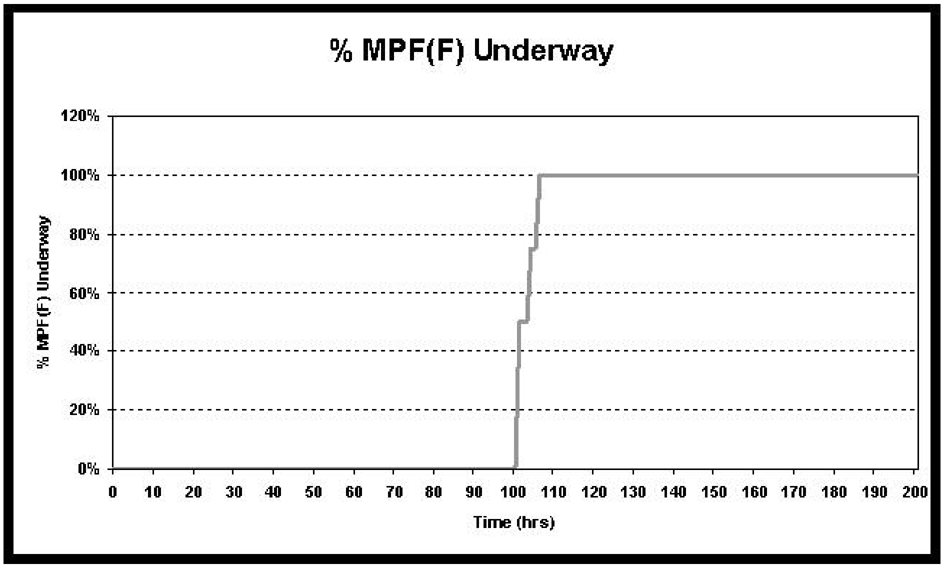

Figure 12-25: Number of MPF(F) ships deployed in time to meet 10-day objective.

COI 2 addresses the assembly requirement for the Closure Phase and involves the loading of the SBME and SBSE aboard the MPF(F) in time to meet the 10-day requirement. A requirement of 127 hrs is necessary for the loading of all personnel and aircraft onto the MPF(F). For personnel, the 2025 Alternative Architecture III completes the loading in approximately 35 hrs, with aircraft on-load lasting 95 hrs.

COI 3 involves the ability of the MPF(F) vessels to get underway from the FLS in time to meet the 10-day requirement. There are no departure delays in the 2025 Alternative Architecture III. MPF(F) ships are underway in 105-hrs. This is a result of all non-self-deploying and MV-22 aircraft being transported onboard the SkyCat™ 1000 and the elimination of CH-53s from the architecture. The CH-53X elimination also eliminates the delay caused by the disassembly and reassembly of these aircraft if transported by strategic airlift.

12.13.2 Employment Phase

The Employment Phase involves delivering 2 surface BLTs and 1 vertical BLT to the objective within a 10-hr period. Air assault connectors deliver 1 vertical BLT, while surface assault connectors deliver the remaining 2 surface BLTs.

COI 5 involves the employment of the SBME to an objective in a 10-hr period. The 2025 Alternative Architecture III delivers the SBME from the Sea Base to the objective, on average, in 8.6 hrs, as seen in Figure 12-26.

Figure 12-26: Employment of SBME at the Objective for the 2025 Alternative Architecture III.

12.13.3 Seize the Initiative

In accordance with the Operating Concept [Chapter 2], the force has 10 days to seize the initiative. In order to seize the initiative, the 2025 Alternative Architecture III must complete the Closure, Assembly, and Employment Phases of operations. COI 6 provides insight into this system requirement.

COI 6 involves the delivery of a JEB from CONUS/Advance Base to the FLS and then to the Sea Base, to include employing 2 surface BLTs and 1 vertical BLT at the objective ashore with a goal of 10 days (240 hrs). The 2025 Alternative Architecture III delivers the combat element of the JEB to the objective in 231 hrs, meeting the 240-hr requirement.

12.13.4 Sustainment Phase

The Sustainment Phase involves delivering supplies from the Sea Base to the objective for a mission time of 30 days. Air assault connectors sustain the JEB at the objective. Additionally, during the 30-day mission time, a resupply ship must also sustain the Sea Base. COIs 7 and 8 provide the sustainment information needed for both the Sea Base and objective to evaluate this system requirement.

COI 7 first addresses the sustainment of the Sea Base for a minimum of 30 days (720 hrs). In 2025 Alternative Architecture III, at no time does any class of supply reach exhaustion. With the addition of the SkyCat™1000 and its role of performing resupply during the Sustainment Phase, the Sea Base is able to maintain supplies above the reserve level. There are no instances when the reserve level for supplies at the Sea Base for provisions and fuel fall below the requirement, as shown in Figures 12-27 and 12-28.

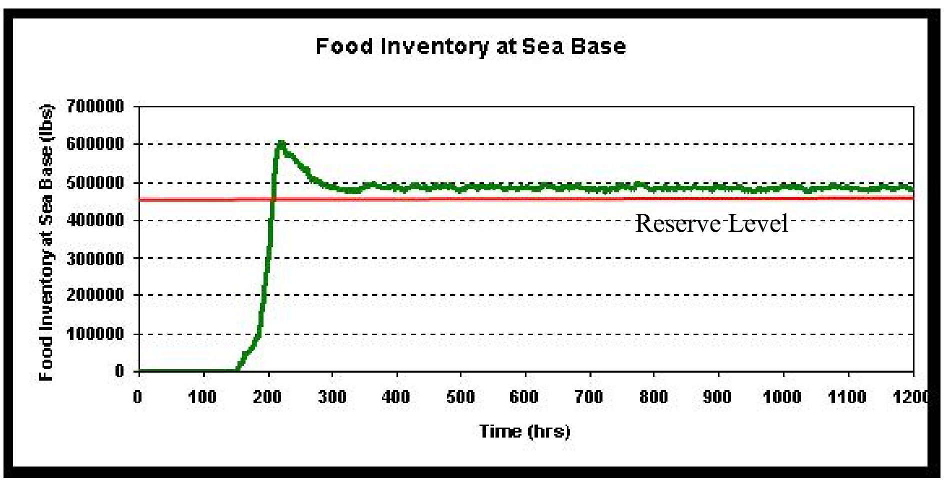

Figure 12-27: Sea Base Provisions Sustainment for the 2025 Alternative Architecture III.

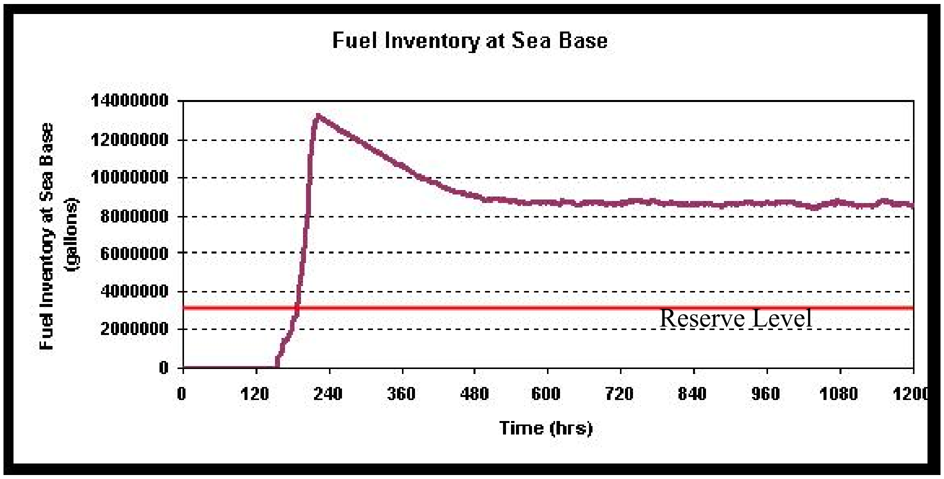

Figure 12-28: Sea Base Fuel Sustainment for the 2025 Alternative Architecture III.

12.13.5 Objective Sustainment

COI 7 also addresses the objective sustainment from the sea for a minimum of 30 days (720 hrs). In 2025 Alternative Architecture III, no class of supply is ever fully exhausted or falls below the critical reserve level during the Sustainment Phase. Another function of COI 7 is the maximum distribution capacity of the SBME. Figure 12-29 indicates that during the initial start of the Sustainment Phase, an oversupply of provisions occurs. This occurs due to model artificiality, in which air connectors begin delivering supplies prior to the exhaustion of the initial supplies delivered during the Employment Phase.

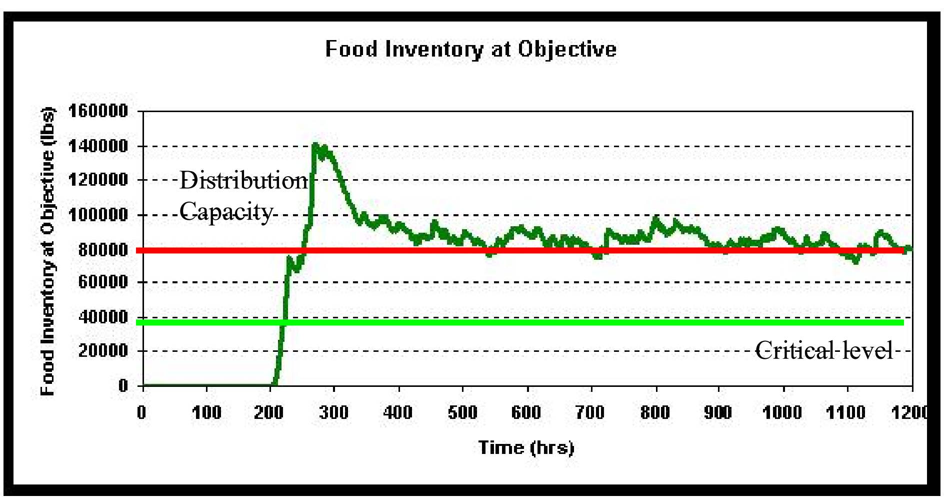

Figure 12-29: Provisions Inventory at the Objective during the Sustainment Phase for the 2025 Alternative Architecture III.

COI 8 addresses sustainment of the objective vertical lift only. The total range from the Sea Base to the objective for the scenario is 150 NM, which is just under the 165 NM maximum range of the MV-22 with external cargo loads. If the range of the objective exceeds the 165 NM range of the MV-22, the ability for vertical sustainment becomes strained. The ATTs have a longer range, but with the limited number of ATTs, the ability to maintain adequate resupply begins to decline.

12.13.6 Medical Evacuation

COI 9 involves the MEDEVAC of the wounded personnel within the Golden Hour (defined in Chapter 2). In 2025 Alternative Architecture III, the doctrine change from using UH-1Y as the primary MEDEVAC platform to assigning the MV-22 and ATT MEDEVAC results in meeting this requirement. On average, 2025 Alternative Architecture III can perform MEDEVAC operations from the objective to the Sea Base within 30 minutes.

12.13.7 Summary

The 2025 Alternative Architecture III uses new concepts that pose potential technology risks. With this unproven technology, 2025 Alternative Architecture III meets the employment of the SBME movement to an objective ashore in a 10-hr period. This is a result of the ATTs augmenting the LCU(R)s and reducing the number of trips and associated transfers with ILP loading. Design Team III was able to meet the closure and sustainment requirements with the additions of the SkyCat™1000 and ATT. ATT operations from an aviation variant MPF(F) allows for the elimination of the CH-53Xs and removes the reliance on strategic airlift and its associated 96-hr time delay. The use of SkyCat™1000 in transporting the MV-22 squadrons eliminates the added maintenance and wear on the aircraft during self-deployment.

12.14 2025 Alternative Architecture III Potential New Issues Created

The use of airships to transport aircraft from CONUS to the FLS has the potential to pose a high technology risk. The emerging lighter-than-air technology being used for

airships has not been tested to military standards nor does it have the ability to land on deployed ships.

The use of ATTs could pose a high technology risk due to the new untested design of the tilt-wing. Landing the ATTs at an unprepared landing site and the stability of the landing surface could pose problems, due to the weight of a fully loaded aircraft. Operationally, the landing of a C-130-sized aircraft in a hot landing zone is an increased risk.

The alongside transfer of materiel from the MPF(F) to the LCU(R) is dependant on sea state. Additionally, 2 ILPs could mean less storage capacity and selective offload must account for 2 debarkation points. The reduced fuel storage capability resulting from the elimination 3 MPF(F) vessels and the increased fuel consumption of fixed wing aircraft will increase the Sea Base refueling requirement.

12.15 Nonmateriel and Materiel Trade Space

During the course of the designing alternative architectures, several nonmateriel and materiel solutions were considered, but ultimately eliminated, for various reasons. Table 12-17 lists the nonmateriel solutions considered and the reason for elimination. Table 12-18 lists the materiel solutions that were eliminated.

Nonmateriel Concepts Eliminated	
Doctrine	Fly all MV-22s to the FLS from the Advance Base vice transporting to FLS. a) Con: Requires additional fuel and manning to support the MV-22. b) Con: Does not optimize the RSLS load capabilities; the RSLS is currently able to carry all MV-22s, CH-53Xs, and other helicopter assets. Rotate aircraft squadrons to the FLS. a) Pro: Eliminates the problem of moving/transporting the aircraft from point of origin to the FLS. This would save valuable time and remove the dependence on strategic airlift assets. b) Con: This will require the establishment of facilities. c) Con: Squadron rotation would be difficult to manage as well as equipment maintenance. d) Con: Training at the FLS would be limited.
Organization	None
Training	None
Leadership	None

Nonmateriel Concepts Eliminated	
Personnel	None
Facilities	Forward-deploy the CH-53X squadrons at or near the FLS locations. a) Pro: Eliminates the problem of moving/transporting the helicopter from point of origin to the FLS. This would save transit time and remove dependence on strategic airlift assets. b) Con: This will require the establishment of facilities for the equipment and personnel to operate and support the installation, squadrons, and increased OPTEMPO. c) Con: The costs of building and operating a CH-53X Advance Base may not prove to be feasible or cost efficient.

Table 12-17: Nonmateriel Solutions Eliminated from Considerations.

Materiel Solution	Materiel Concepts Eliminated
Theater Support Vessel/High Speed Vessel (TSV/HSV)[298]	The TSV is a high-speed, theater transport vessel. Design Team I's analysis of the Army's version of the TSV shows that it has potential to resupply the Sea Base. The TSV Operational Requirements Document (ORD) indicates that this vessel will have greater speed, range and cargo capacity than currently fielded HSV. The analysis used the ORD published numbers for speed, range, and cargo capacity to compare the TSV to the T-AOE in the baseline composition. The TSV has a speed of 40 kts, a range of 8,700 NM at 24 kts and 4,726 NM at 40 kts, and a cargo capacity of 1,500 short tons. It is clear that the TSV offers a greater speed capability, but can it carry enough cargo to take advantage of that speed? Comparing the cargo capacities of both vessels in the three classes of supply results in the following: • Fuel: Approximately 15 TSVs required to hold equivalent weight of barrels of one T-AOE. Additionally, there exists a problem of fuel storage with the TSV. • Ammunition: Approximately 1.2 TSVs required to carry equivalent tons of one T-AOE. • Stores: 0.5 TSV required to carry equivalent tons of one T-AOE. • One T-AOE is equivalent to approximately 17 TSVs in supply capacity. The TSV was eliminated only because 2025 Alternative Architecture I already includes a similar vessel in speed, range, and capacity. The Joint ACCESS has a lesser range and cargo capacity than the TSV, but meets the requirements of the Sea Base described by SEA 6. The analysis of the TSV indicates that continued research in this type of technology can meet capability gaps of logistics. The TSV does not provide adequate air asset transport capability (insufficient height specifically for CH-53X stowage and insufficient area for air wing transport in general). Additionally, this vessel does not possess an adequate beaching capability for use in the Employment Phase.

[298] Tom Worthington, "USAV Spearhead (TSV-1X): High Speed U.S. Army Transport Ship," [database online] (15 October 2003 [cited 14 November 2004]); available from World Wide Web @ http://www.tomw.net.au/2002/tsv1x.

MPF(F) Aviation/ C2 Variant	This variant of the MPF(F) is considered since the Joint ACCESS will be transporting the majority of the JEB going ashore, resulting in the MPF(F) requiring more aviation support for resupply of the objective. Using the analysis of the CNA MPF(F) AoA the design team compares the two aviation variant MPF(F), the Aviation/C2 and the Afloat Forward Staging Base (AFSB). The Aviation/C2 variant has slightly greater aviation parking spots, but fewer operational spots. The aviation capabilities of both ships are similar; therefore, the decision on which variant to select is made in the cargo and fuel carrying capabilities of the ships. The Aviation/C2 is eliminated because the AFSB has greater cargo capacity and fuel storage capabilities.
LHA(R)[299]	The LHA(R) is the replacement for the LHA-1 Wasp class amphibious big deck ships. The first ship in the LHA(R) Program (a modified "Plug Plus" LHD-8[300]) is used for consideration in this alternative architecture. The LHA(R) provides sufficient aviation capability for the MEB ACE. The well deck provides for lower loading times of the LCAC and LCU(R) in the Employment Phase of Sea Base operations. The survivability of the LHA(R) exceeds that any of the other MPF(F) variants because of its self-defense weapons. Elimination of the platform occurs because, compared to the AFSB, the LHA(R) has much less cargo and fuel carrying capacities. In addition, the use of the Joint ACCESS removes the need for a well deck.
AUTOLOG/Extra Heavy Lift UNREP System	The use of Joint ACCESS as a re-supply shuttle ship eliminates the need to transfer bulk material in TEUs from commercial container ships to Sea Base assets. This also eliminates the issue of performing skin-to-skin transfers in high sea states since the Joint ACCESS can conduct UNREPs up to sea state 5+.
Partial Air Cushion Support Catamaran (PACSCAT)	The PACSCAT does not possess a beaching capability for use in the Employment Phase. Also eliminated due to the ship not being designed for open ocean operations.
Affordable Guided Airdrop System (AGAS)	The AGAS system current payload capability is insufficient. If, in the future, it can accommodate large payloads such as vehicles, it may have potential for use in the Employment Phase from large cargo aircraft.
Heavy Landing Craft Air Cushioned (HLCAC)	The HLCAC is used in the initial modeling of Alternative Architecture II and fails to meet the 10-hr requirement during employment. The HLCAC still requires 28 hrs to complete the initial employment. The HLCAC continues to fail the requirement, even with the movement of the departure point for employment from 25 NM to 10 NM. At the 10 NM distance, the total time for employment is still 23 hrs; only a 5-hr time savings.
V-44	Considered, but eliminated due to the high technology risk, based on the MV-22 initial production difficulties.
NAVSTORS	Considered, but not used due to modeling limitations; potentially valuable.

Table 12-18: Materiel Solutions Eliminated from Consideration.

[299] Joint Staff Joint Requirements Oversight Council, "Mission Need Statement for Amphibious Assault Ship (LHA(R)," (Washington, DC: JROCM, 045-01, 05 March 2001).
[300] GlobalSecurity.org, "LHX / LHA (R)" [database online] (18 August 2004 [cited 15 November 2004]); available from World Wide Web @ http://www.globalsecurity.org/military/systems/ship/lhx.htm.

13. Conclusions and Recommendations

13.1 Overview

In order to bring the many pieces of the Joint Expeditionary Logistic Operation (JELo) together, a final link in comparing the different architectures presented so far is needed. A comparison of the architectures with each other, and the criteria associated with each phase, will bring insight in determining which systems are worth consideration for the 2025 notional Sea Base. This chapter analyzes all of the architectures with respect to different performance measures.

Time is the performance metric used to determine success with respect to the system performance standards stated in Chapter 2. The 2015 Baseline Architecture (2015 BLA) and Alternative Architectures are compared against each other to determine which of the four meets the criteria given for each of the different phases of Closure, Employment, Seizing the Initiative, Sustainment, and Medical Evacuation (MEDEVAC).

Analyzing time alone does not give the complete picture. Cost is chosen as a secondary measure to determine if future systems warrant future acquisition expenditures. Cost variability in predicting future complex systems is historically high. The intent of using costing is to establish a means of comparison between architectures as well as aid a decision maker in determining which systems are promising.

The dollar amounts represent the procurement and 10-year operating cost of the specific systems. Complete architecture costing is found in Chapters 7 and 12. The costing represented in this chapter is not the combined cost of all of the architecture's systems. It is, however, an itemized summation of the major contributing systems associated with a given phase. Closure systems such as the Rapid Strategic Lift Ship (RSLS) and Marine Prepositioning Force Future (MPF(F)) are examples of specific closure platforms. Landing Craft Air Cushion (LCAC) and Landing Craft Utility Replacement (LCU(R)) are specific employment systems. Only the high speed assault connector (HSAC) Joint ACCESS has a dual role during the Closure and Employment Phases since it is a major cargo carrier from the Forward Logistic Sites (FLS) to the

Sea Base, as well as a direct Sea Base to Employment platform. This study is to provide insight on the cost and performance of specific systems during each phase, not to determine which of the architectures perform better at a lower cost. Consideration is given to the major contributing systems of the Closure and Employment Phases and these costs are compared against each other using time as the performance metric for each phase.

Technical risk can be used as another metric available in evaluating and comparing different systems. Due to time constraints and resource availability, technical risk is not estimated during this study; however, it was bounded by the use of Advanced Concept Demonstrators (ACDs) and Advanced Concept Technology Demmonstrators (ACTDs) in the alternative architectures.

13.2 General Alternative Architecture Comparison

An architecture overview is provided to give a side by side comparison of the architectures with respect to phase performance.

From Table 13-1, it is apparent all alternative architectures outperform the 2015 BLA at a relatively lower cost. A further analysis of time and cost for each of the major phases will show which of the remaining three architectures holds more promise.

ARCHITECTURE	Closure Time (Days)	Employment Time (Hours)	Seize the Initiative (Days)	Total Cost (FY04$B)
Baseline	16	30	17	$34-$42
Alternative 1	13	10	13	$28-$35
Alternative 2	9	12	10	$29-$36
Alternative 3	9	9	10	$28-$35

Table 13-1: Architecture Summary of Phases and Total Architecture Cost (FY04$B).

13.3 Closure Phase Comparison

The Closure Phase is defined as the elapsed time to form the Sea Base where the requirement of 9.6 days determines success. This criterion is derived from the total time to seize the initiative (10 days) and subtracts the 10-hr goal of employment yielding 9.6 days. The major Closure platforms and systems are various MPF(F) ships, High Speed Assault Connector (HSAC), combat logistic force (CLF) ships, RSLS, strategic airlift (C-5 and C-17), and lighter-than-air heavy lift transports. The most important conclusion from the comparative analysis is a need for a dedicated strategic lift asset. Reliance on nonorganic strategic lift results in a gap of at least 6 days from the criteria goal of 9.6 days.

13.3.1 Closure Phase Performance Comparison

As shown in Figure 13-1, it is clear 2 of the 4 architectures meet the criteria and 2 do not. The 2 that succeed have no reliance on joint strategic airlift, while the other 2 do.

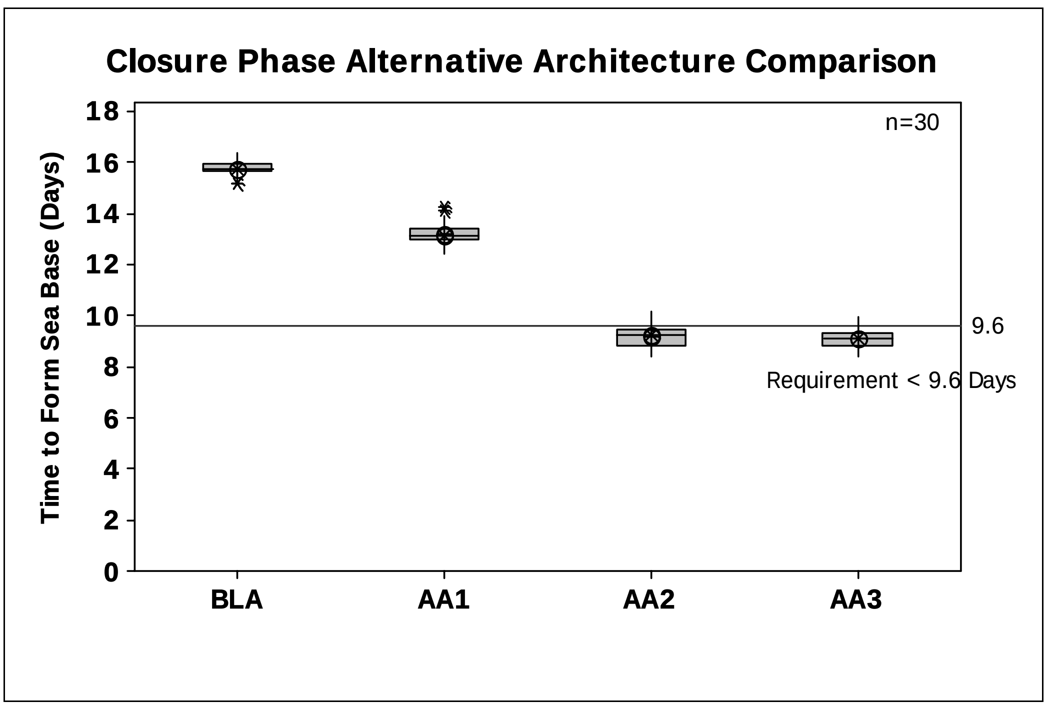

Figure 13-2: Closure Phase Alternative Architecture Comparison.[301]

[301] Refer to the glossary for an explanation of box-plot symbols.

Alternative Architecture I shows a 3-day improvement over the 2015 BLA by utilizing a nonmateriel change of assembling the CH-53X on the MPF(F) while in transit to form the Sea Base vice at the FLS. Both the 2015 BLA and Alternative Architecture I depend on joint strategic airlift to get nondeploying aircraft to the FLS. Preparation of the joint strategic airlift (or establishing an "air bridge") is assumed to take 4 days. Without this 4-day air bridge penalty, Alternative Architecture I succeeds during the Closure Phase by meeting the 9.6 day criteria.

Alternative Architecture II utilizes an RSLS to deliver the non-self-deploying aircraft (NSDA) to the MPF(F) while transiting to/from the Sea Base. The RSLS allows Alternative Architecture II to skip the assembly and reassembly of nondeploying aircraft and avoids the reliance on joint strategic airlift. The use of the RSLS creates a single point of failure. Instead of having the non-self-deploying aircraft transported via multiple platforms, they are all located on a single platform. If the RSLS experiences mechanical problems or other delays, all the required assault air connectors arrive at the Sea Base late. Additionally, if the enemy realizes the RSLS is a center of gravity, there are several instances during the transit that offer opportunities for enemy intervention. Survivability analysis of the RSLS is not published and is recommended for further study.

Alternative Architecture III uses six lighter-than-air vehicles, SkyCats, in transporting the NSDA and eliminates the time-consuming efforts of assembly and reassembly of the aircraft, as well as avoiding the reliance on joint strategic airlift. The utilization of six Skycats reduces the single point of failure associated with the RSLS; however, no real survivability study has been conducted on this type of aircraft. Further survivability and availability studies are needed.

13.3.2 Closure Phase Cost Comparison

The itemized calculations for the major contributing systems of the Closure Phase are presented in Table 13-2. A detailed list of the architecture's systems is found in Chapter 12.

Cost of Architecture's Major Contributing Systems for Closure Phase				
Architecture	**Platform**	**QTY**	**QTY Cost (FY04$)**	**Total Cost (FY04$)**
AA1	MPF(F) Total	4	$6,770,280,991	**$12,529,332,031**
	TSSE HSAC	12	$5,759,051,040	
AA2	MPF(F) Totals	8	$18,190,937,046	**$19,887,416,749**
	RSLS	1	$1,696,479,703	
AA3	MPF(F) Totals	4	$9,546,030,295	**$13,050,032,279**
	MPFF A/C	1	$2,269,016,670	
	Skycat 1000	6	$1,234,985,313	
BLA	MPF(F) Totals:	8	$18,190,937,046	**$18,190,937,046**

Table 13-2: Cost of Architecture's Major Contributing Systems for Closure Phase.

The costs of the contributing closure systems are compared to the elapsed time to close. A comparative chart expressing cost versus performance is given in Figure 13-2.

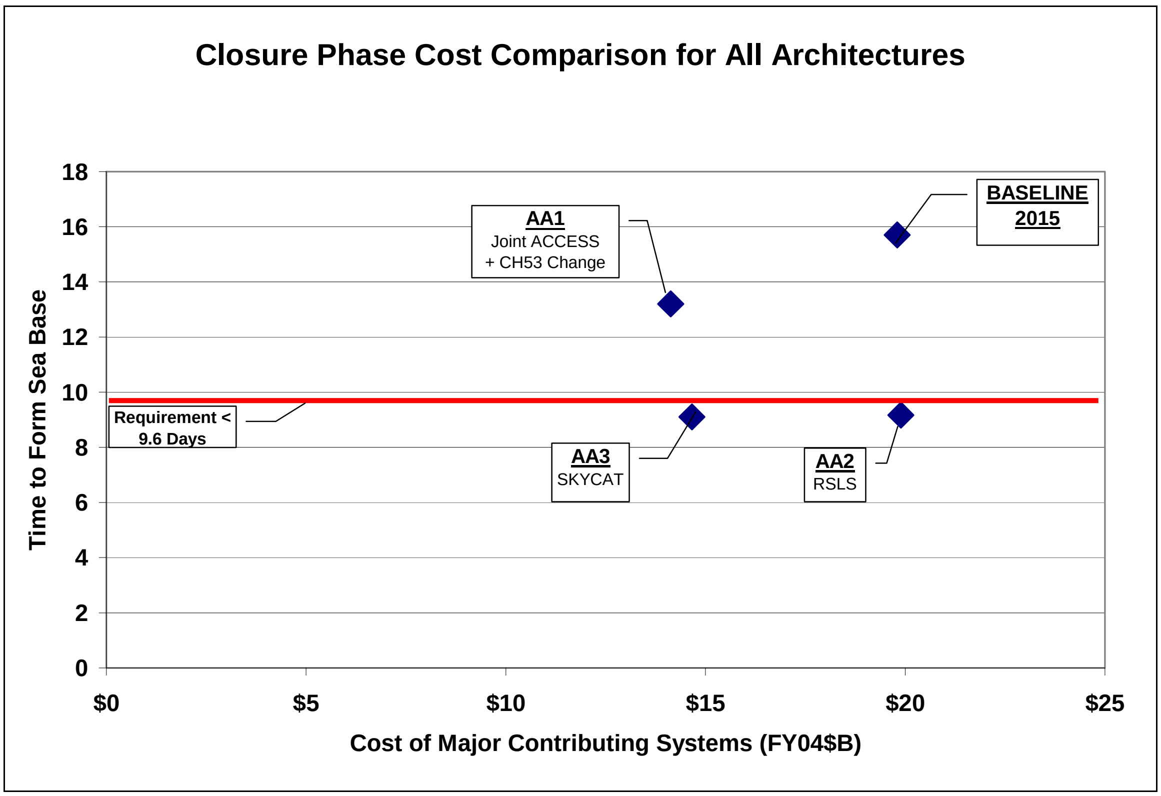

Figure 13-2: Closure Phase Cost Comparison for All Architectures.

It is apparent the 2015 BLA is nearly the most expensive as well as the worst performer. Alternative Architecture I is about the same cost as Alternative Architecture III, but underperforms Alternative Architecture III due to the 4-day penalty for its reliance of the joint strategic airlift. Of the two architectures succeeding in the given Closure criteria of 9.6 days, Alternative Architecture III utilizing

SkyCat is cheaper than Alternative Architecture II RSLS. Again, this cost does not incorporate technical risk or survivability. In order to address these two facets, a complexity factor accounting for risk and survivability is recommended for further study.

13.4 Employment Phase Comparison

The Employment Phase is defined as the elapsed time to complete the initial insertion of three battalion landing teams (BLT) of a Joint Expeditionary Brigade (JEB). Two BLTs are inserted via surface connectors and one BLT by air connector with success measured against the 10-hr criteria to complete insertion. The major Employment platforms are the MV-22, CH-53X, HSAC Joint ACCESS, LCU(R), LCAC, and Advanced Theater Transporter (ATT). The main conclusion from the Employment Phase is that large payload assault connectors improve performance as they reduce the number and/or the requirement for at-sea transfers. The cost associated with this phase favors LCU(R)s over Joint ACCESS and the ATTs.

13.4.1 Employment Phase Performance

All three alternative architectures almost completely close the Employment gap from the 2015 BLA as illustrated in Figure 13.3. The three architectures are nearly equivalent with respect to this metric. One conclusion remains clear: all three alternatives outperform the 2015 BLA and reduce the employment gap to near 0.

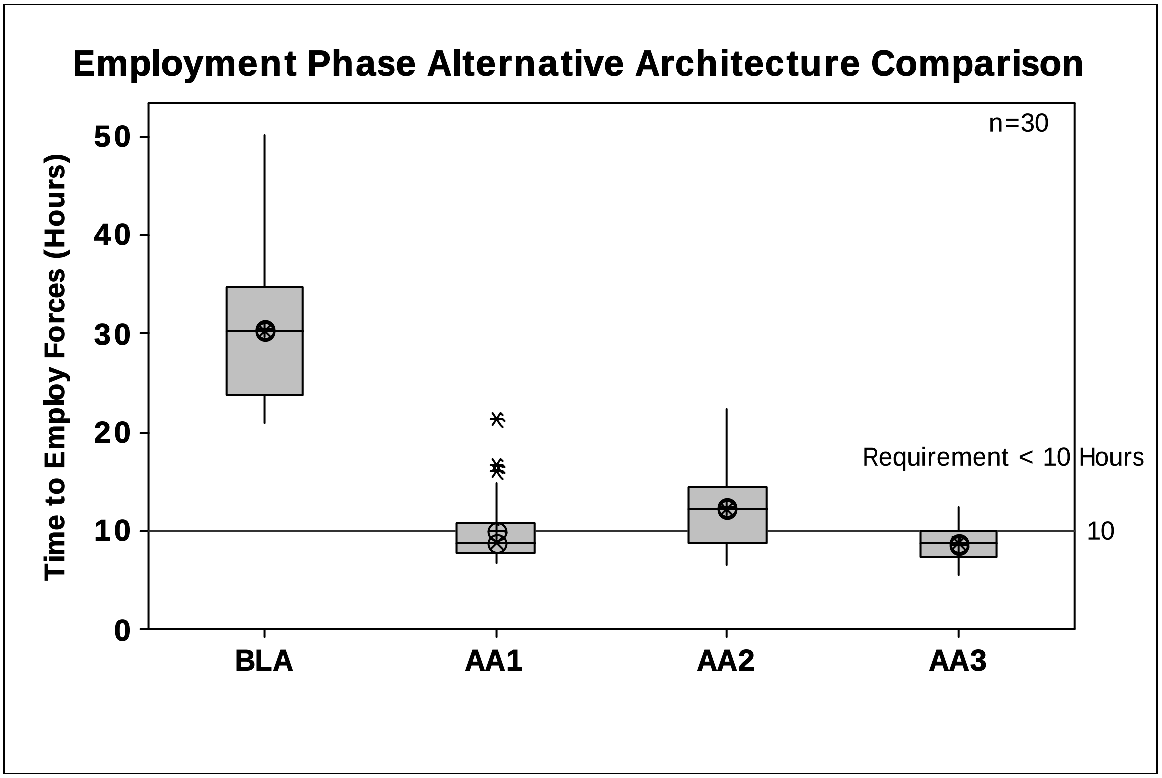

Figure 13-3: Employment Phase All Architectures.

The driving factor during employment is the time spent conducting at-sea transfers. The 2015 BLA uses LCAC as its primary assault connector, which requires 127 total trips and transfers (loading and unloading operations). Alternative Architecture II and Alternative Architecture III use the larger LCU(R) and average between 50 and 60 trips to insert 2 BLTs. Alternative Architecture I utilizes 12 preloaded Joint ACCESS vessels, which are able to off-load 2 BLTs with no additional at-sea transfer. The larger payload of the Joint ACCESS and the LCU(R) yields fewer trips, which reduce the at-sea transfer accompanying each trip.

This insight is further reenforced from the sensitivity study on the impact of at-sea transfer delay during the Employment Phase found in Chapter 11. Starting with an optimistic 30-minute loading delay for each platform, the criterion of 10 hrs is exceeded by 9 hrs. The introduction of a higher payload capacity in the LCU(R) or HLCAC does show some benefit, but this is due to the larger initial equipment load out during the first wave. Increasing payload capacity does not remove the need for at-sea transfer. In fact,

larger payloads require a longer delay in order to load the platform. The transfer system must have the capability to move high volumes of materiel in a short time in varying sea states. A practical operational study is recommended to determine if a transfer system of this capacity is possible.

13.4.2 Employment Phase Cost Comparison

The itemized calculations for the contributing systems of the Employment Phase are given in Table 13-3.

Cost of Architecture's Major Contributing Systems for Employment Phase				
Architecture	**Platform**	**QTY**	**QTY Cost (FY04$)**	**Total Cost (FY04$)**
AA1	TSSE HSAC	12	$5,759,051,040	**$13,669,929,408**
	MV-22	48	$6,371,050,848	
	CH-53X	20	$1,539,827,520	
AA2	MV-22	15	$1,990,953,390	**$5,124,893,655**
	CH-53X	35	$2,694,698,160	
	LCU(R)	16	$439,242,105	
AA3	ATT	8	$991,607,739	**$9,948,504,008**
	MV-22	65	$8,627,464,690	
	LCU(R)	12	$329,431,579	
BLA	MV-22	48	$6,371,050,848	**$9,539,624,119**
	CH-53X	20	$1,539,827,520	
	UH-1Y	9	$495,033,217	
	LCAC	24	$1,078,807,272	
	LCU(R)	2	$54,905,263	

Table 13-3: Cost of Architecture's Major Contributing Systems for Employment Phase.

Taking the cost of the major contributing systems, an analysis is conducted to determine which of these architectures performs better in the given employment criteria. The costs of the contributing employment systems are compared to the elapsed time to insert 3 BLTs. A comparative chart expressing performance versus cost is given in Figure 13-4.

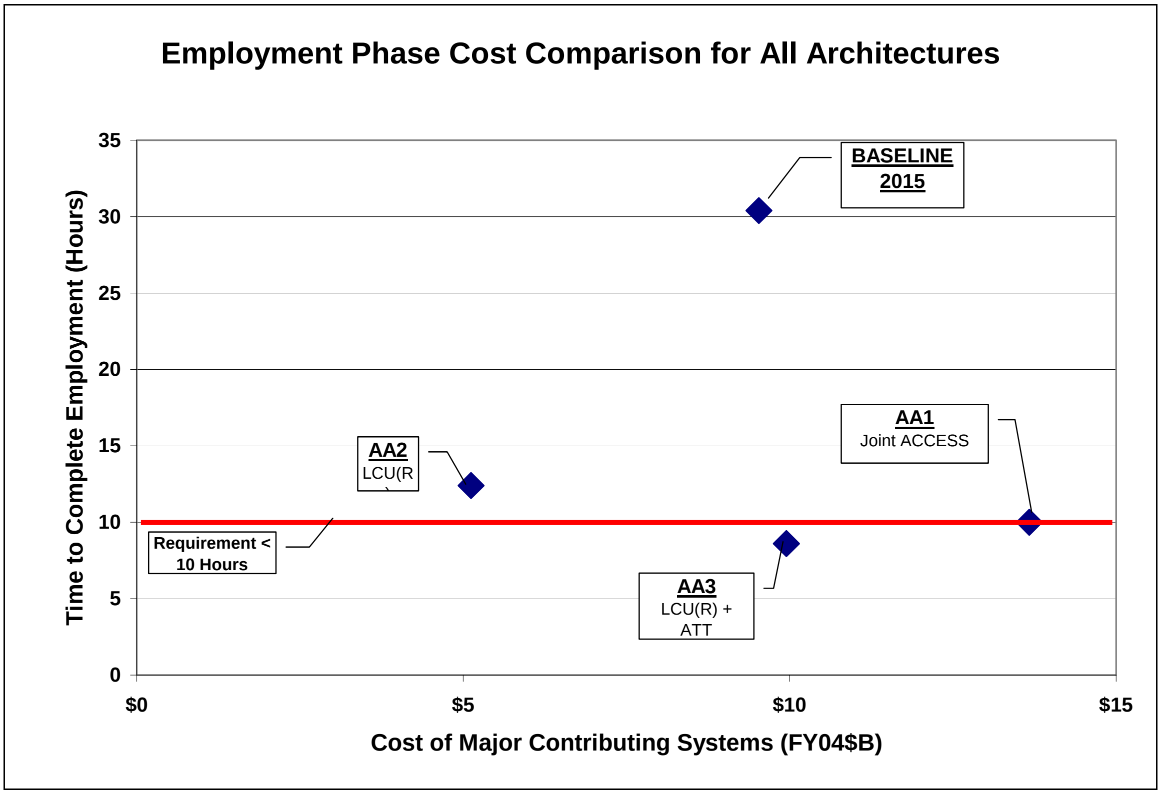

Figure 13-4: Employment Phase Cost Comparison for All Architectures.

Though the 2015 BLA is not the most expensive, its performance gap of 20+ hrs excludes it from further analysis. The remaining architectures have large payload capacity, which reduces the number of at-sea transfer needed. Further insight to Figure 13-4 suggests that the increase in dollar cost is a trade off to reduce at-sea transfers. As mentioned before, Alternative Architecture II and Alternative Architecture III utilize 50-60 at-sea transfers, while Joint ACCESS removes all at-sea transfers during the Employment Phase.

Another explanation to the difference in cost is the level of survivability associated with the platforms. LCU(R) and ATT have limited self-defense capability, while Joint ACCESS provides a full complement of self-defense capability as well as augmenting Sea Shield. Further study on the viability and cost associated with the integrated landing platform (ILP) for at-sea transfer is recommended, as well as the additional cost to harden the LCU(R) and ATT to an acceptable survivability level.

13.4.3 LCU(R) and HLCAC Side Study

In a side study, the LCU(R) is compared to the HLCAC. The LCU(R) outperforms the HLCAC, yielding a 57% increase in performance at a quarter of the cost.

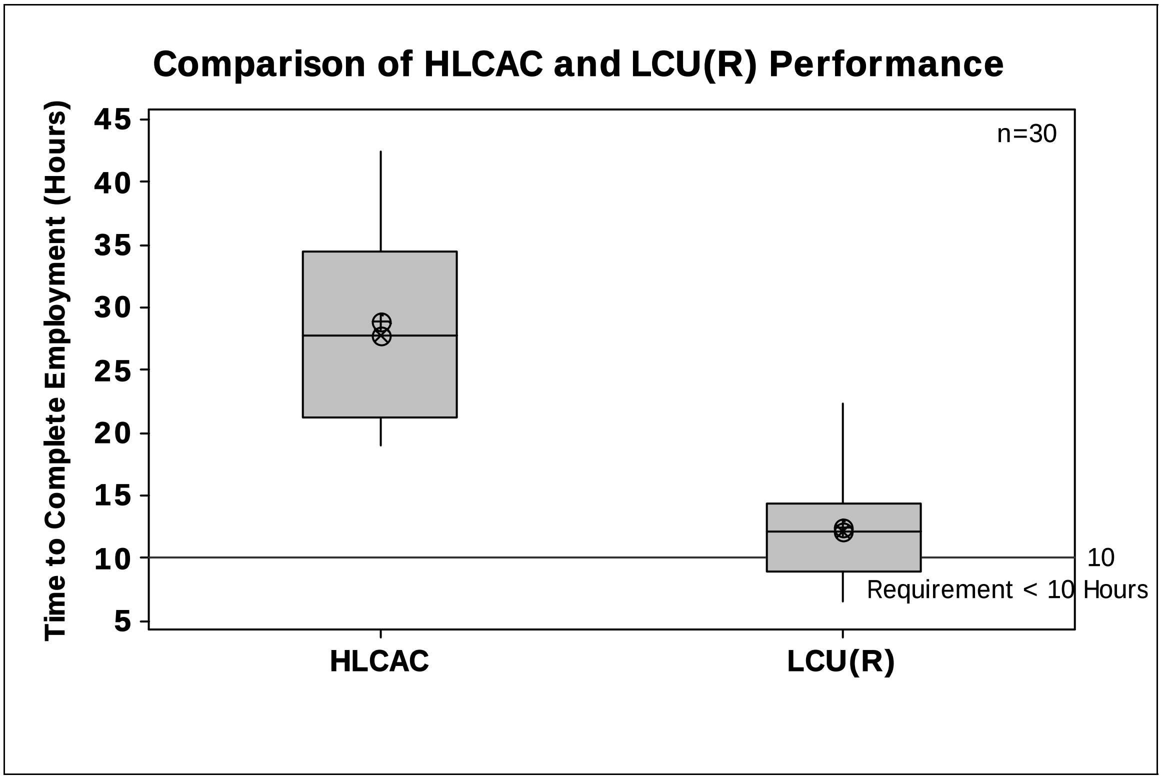

Figure 13-5: Performance Comparison of the HLCAC and LCU(R).

In order to conduct this analysis, a separate model simulation is run keeping all conditions and number of units the same except for the HLCAC and LCU(R) variables and parameters associated with each one. The total acquisition and 10-year operating cost for 16 HLCACs is $1.01 billion (FY04$B) and the cost for 16 LCU(Rs) is $0.27 billion (FY04$B). A trade study is recommended, taking into account the beach accessibility an HLCAC provides over an LCU(R). Only 15%-17% of the world's coastline is compatible for LCU(R), while 70%-80% is compatible for an HLCAC.[302]

[302] U.S. Navy Fact File: Landing Craft, Air Cushioned, [online] (30 December 2003 [cited 09 November 2004]), available from World Wide Web @ http://www.chinfo.navy.mil/navpalib/factfile/ships/ship-lcac.html.

13.5 Seize the Initiative Comparison

The Seize the Initiative Phase is a combination of the Closure and Employment Phases. It is used to measure the overall effectiveness of seizing an initiative within 10 days after the execute order. This measure demonstrates an overview of the combination of materiel and nonmateriel made in each architecture to insert a JEB at an objective. The criterion of 10 days determines success. The main conclusion from the Seize the Initiative Phase repeats the importance of organic strategic lift, as well as reducing at-sea transfer by utilizing high payload capacity assault connectors.

13.5.1 Seize the Initiative Phase Performance

As shown in Figure 13-6, it is clear that 2 of the 4 architectures meet the criteria and 2 do not. The 2 that succeed have no reliance on joint strategic airlift.

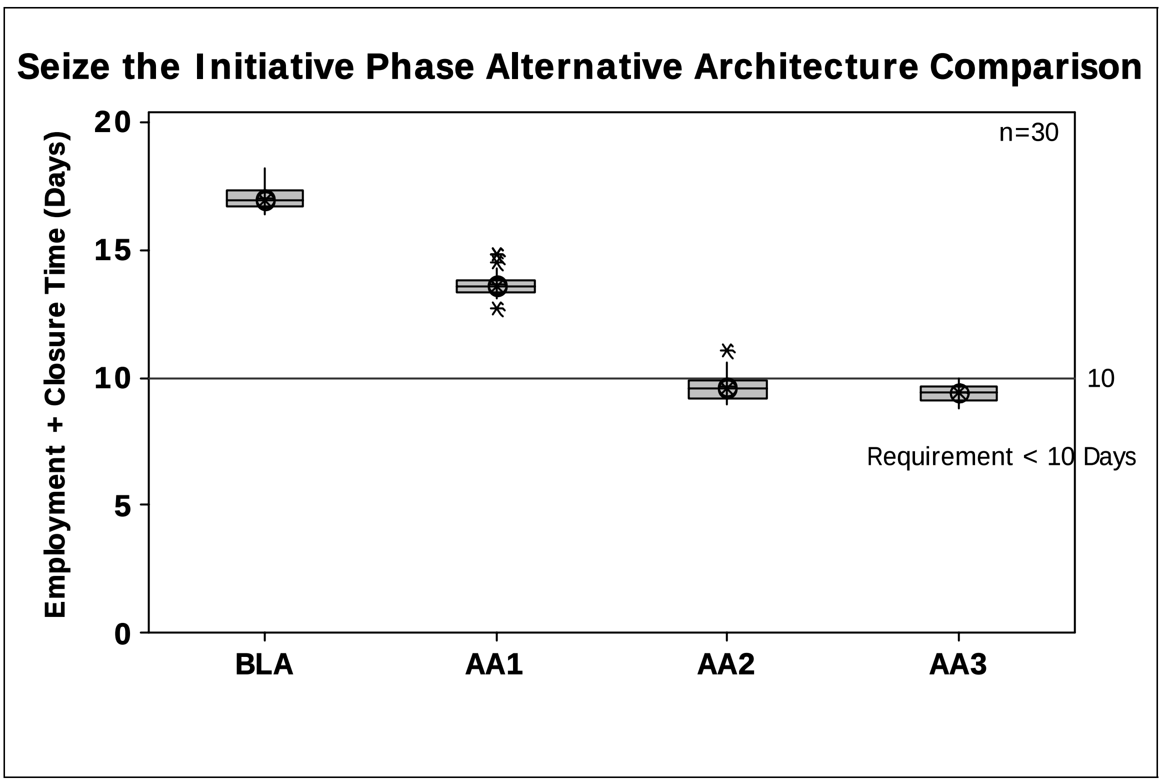

Figure 13-6: Seize the Initiative Phase Alternative Architecture Comparison.

13.5.2 Seize the Initiative Phase Cost Comparison

The itemized calculations for the contributing systems used to seize the initiative are given in Table 13-4.

Cost of Architecture's Major Contributing Systems for Seize the Initiative Phase				
Architecture	**Platform**	**QTY**	**QTY Cost (FY04$)**	**Total Cost (FY04$)**
AA1	MPF(F) Total:	4	$6,770,280,991	**$22,047,859,882**
	TSSE HSAC	12	$5,759,051,040	
	T-AOE	1	$1,607,649,483	
	MV-22	48	$6,371,050,848	
	CH-53X	20	$1,539,827,520	
AA2	MPF(F) Totals:	8	$18,190,937,046	**$25,012,310,404**
	RSLS	1	$1,696,479,703	
	MV-22	15	$1,990,953,390	
	CH-53X	35	$2,694,698,160	
	LCU(R)	16	$439,242,105	
AA3	MPF(F) Totals:	4	$9,546,030,295	**$24,606,185,770**
	MPFF A/C	1	$2,269,016,670	
	T-AOE	1	$1,607,649,483	
	Skycat 1000	6	$1,234,985,313	
	ATT	8	$991,607,739	
	MV-22	65	$8,627,464,690	
	LCU(R)	12	$329,431,579	
BLA	MPF(F) Totals:	8	$18,190,937,046	**$29,338,210,648**
	T-AOE	1	$1,607,649,483	
	MV-22	48	$6,371,050,848	
	CH-53X	20	$1,539,827,520	
	UH-1Y	9	$495,033,217	
	LCAC	24	$1,078,807,272	
	LCU(R)	2	$54,905,263	

Table 13-4: Cost of Architecture's Major Contributing Systems for Seize the Initiative Phase.

The costs of the major contributing systems are compared to the elapsed time to complete closure. A comparative chart expressing cost versus performance is given in Figure 13-7.

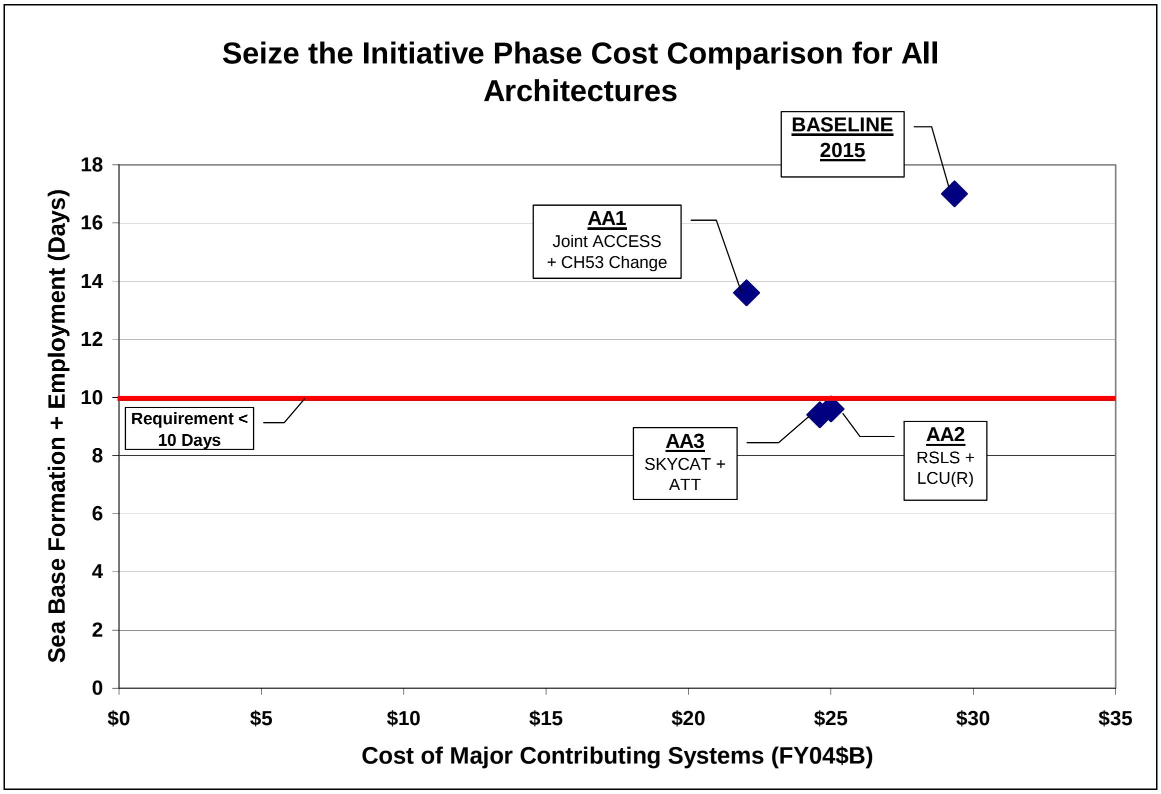

Figure 13-7: Seize the Initiative Phase Cost Comparison for All Architectures.

The Seize the Initiative Phase allows for the full story to be told. Reliance on joint strategic airlift will not allow success in reaching the objecting within 10 days, while the only architectures with organic strategic lift succeed. Again, the 2015 Baseline Architecture is the least capable and most expensive.

13.6 Sustainment Phase

No problems in sustaining the Sea Base or forces at the objective are noted during this analysis. Figures 13-8 and 13-9 show all alternative architectures meet and exceed the goal of maintaining at least 30 days of food, fuel, water, and ammunition at both the Sea Base and objective.

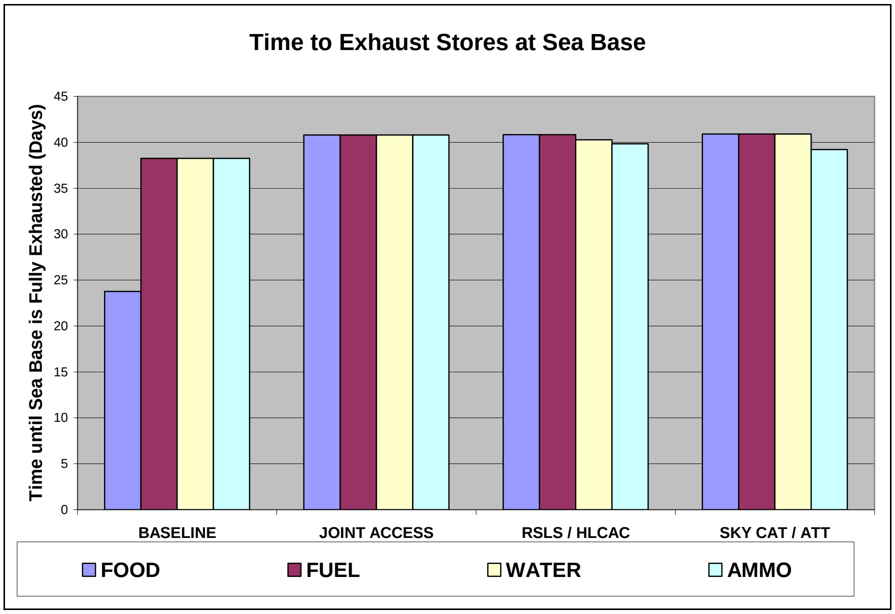

Figure 13-8: Time to Exhaust Stores at Sea Base.

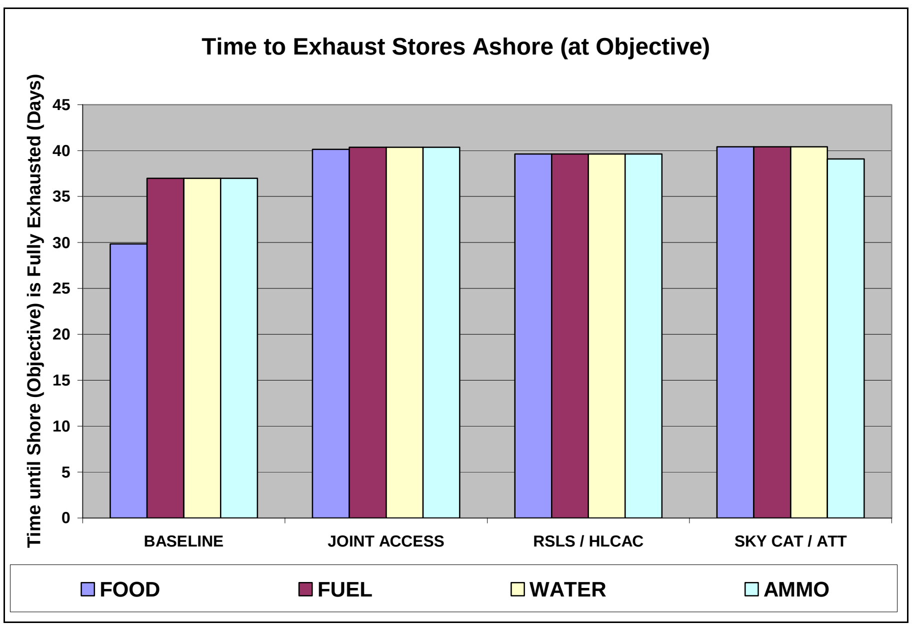

Figure 13-9: Time to Exhaust Stores Ashore.

Additional insights on the number of deck spots needed and delay time associated with loading and refueling sustainment platforms are found during the sensitivity analysis in Chapter 11. The data from the study suggests that a minimum of six dedicated logistic aircraft deck spots are required amongst the MPF(F) to be in operation over a 24-hr period, for 30 days, to sustain the objective from 150 NM from the Sea Base.

These dedicated logistic deck spots will be in competition for availability with nonlogistical operational service aircraft and a study is recommended to determine the total number of deck spots needed to support logistical and nonlogistical operations from the Sea Base.

In keeping with Marine Corps operating objectives, sustainment must be accomplished up to 200 NM from the objective. The MV-22 aircraft does not possess the heavy lift capability at ranges greater than 150 NM. The sensitivity analysis suggests that 50 CH-53X-equivalent aircraft, dedicated specifically for logistic operations, are required to sustain at least one day of supplies from 200 NM to the objective.

13.7 MEDEVAC Phase Performance Comparison

All three alternative architectures utilized the MV-22 as the primary MEDEVAC transporter and all three exceeded the criteria of 1 hr. There is no statistical difference between the architectures. It is recommended the MV-22 aircraft assume the role as primary MEDEVAC platform as illustrated in Figure 13-10.

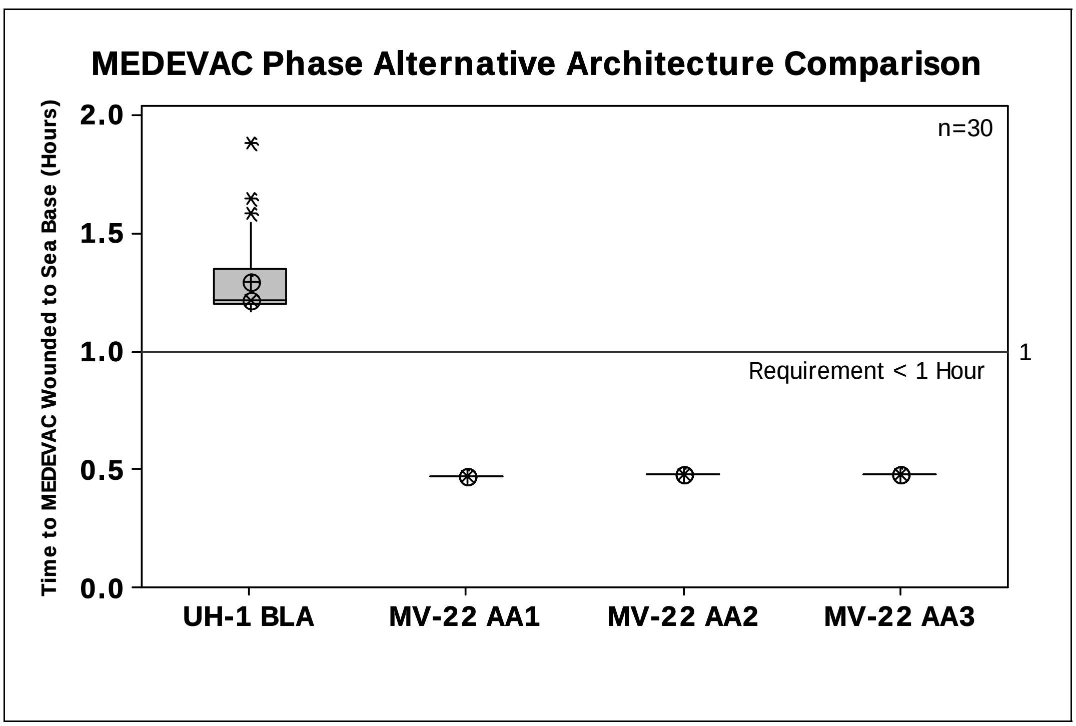

Figure 13-10: MEDEVAC Phase Alternative Architecture Comparison.

13.8 Recommendation Summary

Finally, the following is a summary of the recommendations for further study SEA-6 suggests from the results experienced during this project.

- Explore a Unified Expeditionary Command concept. An additional component command, comprised of the required dedicated strategic and assault assets, is recommended to be able to react and respond to the envisioned expeditionary war in 2025, such as U.S. Special Operations Command's (USSOCOM) ownership of their dedicated assets in supporting geographic commands, ambassadors, and their country teams.
- Conduct a trade study on alternative command structures to share resources if the above is not realistic.
- Consider SkyCat and other airship concepts. Though these airships have shown some promise in our study, a survivability and reliability analysis is recommended to determine if they can be applied in a military context.
- Further analyze the survivability of the MPF(F), RSLS, and other dedicated sealift concepts to determine the magnitude of specific self-defense and damage control capability needed to meet military survivability criteria or if these vessels could be escorted with nonorganic self-defense assets.
- Consider alternative vertical lift compositions in order to utilize high-speed troop transporters (MV-22) during employment, then reallocate where they are needed, as they are not suitable for the heavy lift requirements (specifically external bulk payload) during sustainment.
- Conduct a trade study of MPF(F) selective off-load technology versus manning, overall cargo capacity, and survivability. Selective off-load needs to stay in step with the future manning force to operate and support. Selective off-load requires large storage compartments to compensate its poor space utilization, which implies damage control and survivability complexity.

- Develop a conceptual design for a Sea Base Common Logistics Picture (CLP) architecture needed for real time data flow for sense and respond logistic operations to avoid "Iron Mountains."
- Conduct at-sea experimentation to measure transfer performance with varying sea state to determine operation practicability and affordability for tactical at-sea transfer (specifically the ILPs).
- Conduct SEABASE-6 model fractional factorial experiment to determine interaction of key design features to provide further insight on the degree of impact a certain platform parameter has on the system since this study varied external Sea Base factors and not specific platforms.

Appendix A: Bibliography

"15th MEU Official Photo 2001620225452." MarineNet Online Learning. n.d. <www.15meu.usmc.mil/marinelink/image1.nsf/lookup/2001620225452> (27 September 2004).

"2nd Marine Expeditionary Brigade Task Force Tarawa." GlobalSecurity.org. 02 August 2004. <http://www.globalsecurity.org/military/agency/usmc/2meb.htm> 20 November 2004.

"7.62mm Ammo Box." Surplus Center, Burden Sales Co. n.d. <http://www.surpluscenter.com/item.asp?UID=2004121215215774&item=1-1121&catname=misc> (05 October 2004).

"82nd Airborne Division." GlobalSecurity.org. 02 August 2004. <http://www.globalsecurity.org/military/agency/army/82abn.htm> (20 November 2004).

Aboulafia, Richard. "Rethinking U.S. Air Power." Aerospace America. March 2001. <http://www.aiaa.org/aerospace/Article.cfm?issuetocid=66&ArchiveIssueID=11> (12 November 2004).

Acquisition Logistics Guide. December 1997. <http://www.dau.mil/pubs/gdbks/acqulogguide.asp> (01 October 2004).

"Advanced Auxiliary Dry Cargo Ships – T-AKE." United States Navy: Fact File. 15 September 2003. <http://www.chinfo.navy.mil/navpalib/factfile/ships/ship-take.html> (16 September 2004).

"Advanced Technologies Group: SkyCat Hybid Air Vehicle, United Kingdom." Aerospace-technology.com. n.d. <http://www.aerospace-technology.com/projects/skycat/> (22 October 2004).

"Advanced Theater Transport." GlobalSecurity.org. 01 December 2002. <http://www.globalsecurity.org/military/systems/aircraft/att.htm> (23 November 2004).

"Advanced Theater Transport." GlobalSecurity.org. 08 November 2001. <http://www.globalsecurity.org/military/systems/aircraft/att-pics.htm> (16 November 2004).

"AH-1 Cobra." GlobalSecurity.org. 30 September 2004. <http://www.globalsecurity.org/military/systems/aircraft/ah-1.htm> (02 October 2004).

"Air Mobility Command, Chapter 2." Unit Air Movement Planning – Change 1. Army Field Manual No. 55-9, Headquarters, Department of the Army, Washington, DC, 05 April 1993. <http://www.globalsecurity.org/military/library/policy/army/fm/55-9/ch2.htm> (10 November 2004).

Albright, Brian. "Military Releases Final RFID Policy". Frontline. 17 August 2004. <http://www.frontlinetoday.com/frontline/article/articleDetail.jsp?id=114683> (21 September 2004).

The American Practical Navigator. Bethesda, MD: National Imagery and Mapping Agency, 1995.

"Amphibious Assault Ships LHA/LHD/LHA(R)." United States Navy: Fact File. 30 December 2003. <http://www.chinfo.navy.mil/navpalib/factfile/ships/ship-lha.html> (12 September 2004).

"Amphibious Assault Ships (LHA), Tarawa Class." NAVSEA Program Executive Office (PEO) Ships. 11 November 2004. <http://peoships.crane.navy.mil/fleetsupport/lha.htm> (12 November 2004).

Arena, Mark V., John F. Schank, and Megan Abbott. The Shipbuilding & Force Structure Analysis Tool; A User's Guide. Santa Monica, CA: RAND, National Defense Resource Institute, 2004.

Aviation Logistics. Marine Corps Warfare Publication 3.21.2, PCN 143 000102 00, 21 October 2002.

Barnard, Richard C. "Sea Basing Concept Promises a Revolution in Power Projection." Navy League of the United States. June 2004. <http://www.navyleague.org/sea_power/jun_04_10.php> (1 September 2004).

Bell Helicopter Textron Inc. UH-1Y Pocket Guide. September 2004. <http://www.bellhelicopter.textron.com/en/aircraft/military/pdf/UH1Y_PG_04_web.pdf> (04 December 2004).

Bellinger, Gene. Modeling and Simulation. Outsights, Inc., 2004.

Blanchard, Benjamin S., and Wolter J. Fabrycky. Systems Engineering and Analysis, 3rd edition. Upper Saddle River, New Jersey: Prentice Hall, 1998.

Boyd, Guinevere, Naval Surface Warfare Center, Carderock Division (NSWCCD). Personal interview. 20 October 2004.

"C-130 Hercules." Air Force Link. September 2003. <http://www.af.mil/factsheets/factsheet.asp?fsID=92> (12 September 2004).

"C-130 Hercules." GlobalSecurity.org. 12 October 2004. <http://www.globalsecurity.org/military/systems/aircraft/c-130-pics.htm> (17 November 2004).

"C-130 Hercules." United States Navy: Fact File. 10 May 1999. <http://www.chinfo.navy.mil/navpalib/factfile/aircraft/air-c130.html> (12 September 2004).

"C-130H Specifications." GlobalSecurity.org. 08 November 2001. <http://www.globalsecurity.org/military/systems/aircraft/c-130-specs.htm> (10 November 2004).

"C-130J Specifications and Performance." GlobalSecurity.org. 31 October 2001. <http://www.globalsecurity.org/military/systems/aircraft/c-130j-specs.htm> (04 October 2004).

"C-17 Globemaster III." Air Force Link. October 2004. <http://www.af.mil/factsheets/factsheet.asp?fsID=86> (12 October 2004).

"C-17 Globemaster III Production." GlobalSecurity.org. 11 December 2004. <http://www.globalsecurity.org/military/systems/aircraft/c-17-prod.htm> (11 December 2004).

"C-5 Galaxy." Air Force Link. August 2003. <http://www.af.mil/factsheets/factsheet.asp?fsID=84> (12 October 2004).

Carey, Neil, James Grefer, Robert Trost, and Robert Levy. Future Deployable Medical Capabilities and Platforms for Navy Medicine. Alexandria, VA: The CNA Corporation, CRM D0005085.A2/Final, February 2002.

Carter, Mike, Major, U.S. Marine Corps. <macarter@nps.edu> "RE: CH-53 pilot question." 02 November 2004. Office communication (02 November 2004).

Central Intelligence Agency. "Burma." The World Factbook. 30 November 2004. <http://www.cia.gov/cia/publications/factbook/geos/bm.html> (December 2004).

"CH-53 Sea Stallion." FAS Military Analysis Network. 07 January 1999. <http://www.fas.org/man/dod-101/sys/ac/h-53.htm> (26 September 2004).

"CH-53D Sea Stallion." United States Navy: Fact File. 17 May 1999. <http://www.chinfo.navy.mil/navpalib/factfile/aircraft/air-ch53d.html> (12 September 2004).

"CH-53E Super Stallion." GlobalSecurity.org. 09 March 2004. <http://www.globalsecurity.org/military/systems/aircraft/ch-53e.htm> (05 October 2004).

"Chapter One Introduction to Special Operations." SOF Reference Manual. n.d. <http://www.fas.org/irp/agency/dod/socom/sof-ref-2-1> (June 2004).

"Civil Reserve Air Fleet." GlobalSecurity.org. 18 November 2001. <http://www.globalsecurity.org/military/systems/aircraft/craf.htm> (18 October 2004).

Clark, Vern, Admiral, U.S. Navy. "Sea Power 21: Projecting Decisive Joint Capabilities." Proceedings. October 2002. <http://www.usni.org/PROCEEDINGS/ARTICLES02/proCNO10-2.htm#seabasing> (27 September 2004).

"Classes and Subclasses of Supply." GlobalSecurity.org. 29 September 2002. <http://www.globalsecurity.org/military/intro/supclass.htm> (15 November 2004).

Colton, Tim. "U.S. Government Shipbuilding – Auxiliary Ships." 23 October 2004. <http://www.coltoncompany.com/shipbldg/ussbldrs/postwwii/government/auxiliaries> (29 October 2004).

Colton, Tim. "U.S. Government Shipbuilding – Landing Craft-Air Cushion (LCAC)." 08 June 2003. <http://www.coltoncompany.com/shipbldg/ussbldrs/postwwii/government/lcac.htm> (18 October 2004).

Cote, Robert E., Major, U.S. Marine Corps. <CoteRE@bic.usmc.mil> "RE: MPF(F) studies at NPS." 04 October 2004. Office communication (19 October 2004).

Csontos, Aladar A., and Burnham C. McCaffree, Jr. The Combat Logistics Force Response to Operation Enduring Freedom. Alexandria, VA: The CNA Corporation, CRM D0007211.A2/Final, March 2003.

Csontos, Aladar A., and Carl Douglas. The Naval Operational Logistics System and Issues Affecting It. Alexandria, VA: The CNA Corporation, CIM D0005087, March 2002.

"CVN Cargo Movement Process Study." Data from Naval Surface Warfare Center, Carderock Division (NSWCCD), November 2002.

Defense Acquisition University. Cost Estimating. 17 February 2004. <http://acc.dau.mil/simplify/ev.php?ID=1437_201&ID2=DO_TOPIC> (15 September 2004).

Defense Acquisition University. Glossary: Defense Acquisition Acronyms and Terms. September 2003. <http://www.dau.mil/pubs/glossary/preface.asp.> (02 October 2004).

Defense Budget Materials: FY2005 Budget. 10 March 2004. <http://www.dod.mil/comptroller/defbudget/fy2005/index.html> (18 October 2004).

Defense Science Board Task Force on Logistics Transformation – Phase II. Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Washington, DC, January 2001.

Defense Science Board Task Force on Sea Basing. Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Washington, DC, August 2003.

Department of Defense (DoD) Architecture Framework Working Group. DoD Architecture Framework (DODAF) Version 1.0, Volume I: Definitions and Guidelines. 30 August 2003. <http://www.teao.saic.com/jfcom/ier/documents/dod_framework_vol_1.pdf> (12 September 2004).

Devore, Jay L. Probability and Statistics for Engineering and the Sciences, 5th edition. Pacific Grove, CA: Duxbury, Thomson Learning, 2000.

Diamond, Bob. EXTEND™ v6 Professional Simulation Tools, User's Guide. San Jose, CA: Imagine That, Inc., 2002.

DOD Dictionary of Military Terms. n.d. <http://www.dtic.mil/doctrine/jel/doddict/index.html> (23 September 2004).

DoD Directive 5000.1 – The Defense Acquisition System. 12 May 2003. <http://akss.dau.mil/darc/darc.html> (01 October 2004).

DoD Directive 5000.2 – Operation of the Defense Acquisition System. 12 May 2003. <http://akss.dau.mil/darc/darc.html> (1 October 2004).

DoD Directive 5000.4M – Cost Analysis Guidance and Procedures. December 1992. <http://www.ncca.navy.mil/resources/guidance.cfm> (30 September 2004).

England, Gordon, Secretary of the Navy, Admiral Vern Clark, U.S. Navy, Chief of Naval Operations, and General James Jones, U.S. Marine Corps, Commandant of the Marine Corps. The Naval Transformation Roadmap. July 2002.

Expeditionary Maneuver Warfare Concepts for Resupply of Marine Corps Cargo to Sea-Based ARG/MPF Ships. Underway Replenishment Department Port Hueneme Division Naval Surface Warfare Center, January 2002.

"Expeditionary Strike Group." GlobalSecurity.org. 02 August 2004. <http://www.globalsecurity.org/military/agency/navy/esg.htm> (20 November 2004).

"Expeditionary Warfare Logistics Study." Unpublished Memorandum, Deputy Chief of Naval Operations for Warfare Requirements and Programs (OPNAV N7), 2004.

"F/A-18 Hornet." United States Navy: Fact File. 21 March 2003. <http://www.chinfo.navy.mil/navpalib/factfile/aircraft/air-fa18.html> (14 September 2004).

FAS Military Analysis Network. Advanced Theater Transport. 02 January 1999. <http://www.fas.org/man/dod-101/sys/ac/att.htm> (03 November 2004).

"Fast Combat Support Ships – T-AOE." United States Navy: Fact File. 30 June 2004. http://www.chinfo.navy.mil/navpalib/factfile/ships/ship-taoe.html> (20 September 2004).

"Fast Combat Support Ships (T-AOE), Supply Class." NAVSEA Program Executive Office (PEO) Ships. 11 November 2004. <http://peoships.crane.navy.mil/fleetsupport/taoe.htm> (04 November 2004).

Fleet Logistics Operations Branch (Code 4121H). Naval Supply Procedures, Volume I: Afloat Supply. Naval Supply Systems Command, NAVSUP Publication 485 (NAVSUP P-485), 21 October 1997.

Fontenot, Gregory, E.J. Degen, and David Tohn. "On Point - The United States Army in Operation Iraqi Freedom." On Point. n.d. <http://www.globalsecurity.org/military/library/report/2004/onpoint/ch-2.htm#deployment> (23 September 2004).

Foss, John W., General, U.S. Army (retired). "Challenge for Operations Research in the Coming Decade." Phalanx Online (Military Operations Research Society newsletter), March 1994.

Frey, Chris. An Evaluation of Sea-Based Sustainment of Forces. Monterey, CA: Naval Post Graduate School Thesis, September 2000.

Gates, Jim. "Introduction to Cost Analysis" (teaching notes online). April 2004. <http://acc.dau.mil/simplify/ev.php?ID=19844_201&ID2=DO_TOPIC> (01 October 2004).

"Global Hawk." Air Force Link. April 2003. <http://www.af.mil/factsheets/factsheet.asp?fsID=175> (14 September 2004).

"Glossary of Terms/Acronyms." Army Enterprise Transformation Guide. 02 August 2004. <http://www.army.mil/aeioo/toolkits/glossary.html> (08 September 2004).

Gossett, Mark. Account Training and Logistics Distribution Training. Headquarters, U.S. Air Force, April 2002.

Gregor, Tom. C-130 Hercules. 11 April 2004. <http://www.scenery.org/c-130.htm.> (17 November 2004).

Headquarters, U.S. Marine Corps Plans, Policies, and Operations Department (Maritime & Geographic Prepositioning Section [POE-60]). Update 2015 "Baseline" MEB Organization. n.d. <http://hqinet001.hqmc.usmc.mil/pp&o/POE/POE-60/MPF-F/Updated%202015%20MPF(F)%20MEB.ppt> (18 August 2004).

"HH/UH-1N Iroquois." United States Navy: Fact File. 03 September 2002. <http://www.chinfo.navy.mil/navpalib/factfile/aircraft/air-uh1.html> (14 September 2004).

Hicks, Charles R. Fundamental Concepts in the Design of Experiments, 2nd edition. New York: Holt, Rinehart and Winston, 1973.

"High Mobility Multipurpose Wheeled Vehicle (HMMWV) (M998 Truck)." GlobalSecurity.org. January 2003. <http://globalsecurity.org/military/systems/ground/hmmwv-specs.htm> (09 December 2004).

Hoivik, Thomas H. OA-4603 Test and Evaluation Lecture Notes, Version 6.0. Monterey, CA: Naval Postgraduate School, 2004.

Hoivik, Thomas H., Captain, U.S. Navy (retired). <thhoivik@nps.edu> "RE: SEA-6 project question." 02 November 2004. Office communication (02 November 2004).

Hopkins, J. I., Major General, U.S. Marine Corps. "This Was No Drill." Proceedings, November 1991.

International Council on Systems Engineering (INCOSE). What is Systems Engineering. 04 June 1999. <http://66.34.135.97/whatis.html> (03 November 2004).

Jackson, Paul, editor. Jane's All the World's Aircraft 2004-2005. Alexandria, VA: Jane's Information Group, Inc., 2004.

Jerousek, Albert E., III, Chief Warrant Officer 3, U.S. Marine Corps, Expeditionary Warfare Training Group, Pacific (EXPWARTRAGRUPAC). <albert.jerousek@navy.mil> "MEU Assault Timeline." 09 November 2004. Office communication (11 November 2004).

"Joint Campaign Analysis Book 1 – Student Text." Unpublished Student Text, Operations Research Department, Naval Postgraduate School, Monterey, CA, 1999.

Joint Capabilities Integration and Development System. Chairman of the Joint Chiefs of Staff Manual 3170.01D (CJCSM 3170.01D), 12 March 2004.

Joint Logistics Petroleum Planning Guide. Fort Lee, VA: Petroleum and Water Department, U.S. Army Quartermaster Center and School, June 2003.

Joint Military Operations Brief. Headquarters, Department of the Army, 26 August 2004.

Joint Operations Concepts. Director for Operational Plans and Joint Force Development, Joint Staff J-7 Joint Vision and Transformation Division Pentagon, Washington, DC, November 2003.

"Joint Strike Fighter (JSF)." GlobalSecurity.org. 11 March 2002. <http://www.globalsecurity.org/military/systems/aircraft/jsf.htm> (02 October 2004).

"Joint Strike Fighter (JSF) Specifications." GlobalSecurity.org. 08 November 2001. <http://www.globalsecurity.org/military/systems/aircraft/jsf-specs.htm> (18 October 2004).

Joint Total Asset Visibility (JTAV). 2001. <http://www.dla.mil/j-6/jtav/default.htm> (10 October 2004).

Kaskin, Jonathan, Director Strategic Mobility/Combat Logistics Division/N42. "Rapid Strategic Lift Ship (RSLS)." Unpublished Brief, 08 March 2004.

Kline, Jeff E. "Measures of Effectiveness." Unpublished lecture notes, OS3680 Naval Tactical Analysis course, Naval Postgraduate School, Monterey, CA, 30 September 2003.

"Landing Craft, Air Cushioned." United States Navy: Fact File. 30 December 2003. <http://www.chinfo.navy.mil/navpalib/factfile/ships/ship-lcac.html> (12 September 2004).

"Landing Craft, Air Cushion (LCAC)." GlobalSecurity.org. 17 July 2004. <http://www.globalsecurity.org/military/systems/ship/lcac.htm> (02 October 2004).

"Landing Craft, Air Cushion (LCAC)." GlobalSecurity.org. 09 August 2004. <http://www.globalsecurity.org/military/systems/ship/lcac-specs.htm> (05 October 2004).

"Landing Craft, Air Cushioned (LCAC)." NAVSEA Program Executive Office (PEO) Ships. 11 November 2004. <http://peoships.crane.navy.mil/fleetsupport/lcac.htm> (04 November 2004).

"Landing Craft, Mechanized and Utility – LCM/LCU." United States Navy: Fact File. 03 May 1999. <http://www.chinfo.navy.mil/navpalib/factfile/ships/ship-lcu.html> (15 September 2004).

"Landing Craft Utility (LCU)." GlobalSecurity.org. 18 August 2004. <http://www.globalsecurity.org/military/systems/ship/lcu.htm> (02 October 2004).

"Landing Craft Utility (LCU): LCU-X/LCU(R)." GlobalSecurity.org. 18 August 2004. <http://www.globalsecurity.org/military/systems/ship/lcu-x.htm> (04 October 2004).

Law, Averill M. and David W. Kelton. Simulation Modeling and Analysis, 3rd edition. Boston: McGraw Hill, 2000.

LHA/LPH/LHD NATOPS Manual. Naval Air Systems Command, NAVAIR 00-80T-106, 01 June 1998.

"LHX / LHA (R)." GlobalSecurity.org. 18 August 2004. <http://www.globalsecurity.org/military/systems/ship/lhx.htm> (15 November 2004).

Linkowitz, Nick, Head Logistics Vision Team, Headquarters, U.S. Marine Corps. "Joint Modular Intermodal Container (JMIC)." PowerPoint Brief, Headquarters, U.S. Marine Corps, 07 July 2004.

Logistics Automatic Identification Technology Concept of Operations. Deputy Under Secretary of Defense (logistics), AIT Task Force, November 1997.

Lozano, J. Mark, Captain, U.S. Marine Corps. <jmlozano@nps.edu> "RE: CH-53 Transport Times." 01-02 November 2004. Office communication (02 November 2004).

Lugo, John, Jan Nilsen, Robert Perez, and Joel Tessier. Logistics Support of Expeditionary Units. Monterey, CA: Naval Postgraduate School MBA Professional Report, December 2004.

Macey, Paul, Design Engineer, Advanced Technologies Group, Ltd. <P.Macey@ConnectFree.co.uk> "SkyCat." 27-28 October 2004. Office Communication, (28-29 October 2004).

Maloney, Ken. LCU(R) Planing Landing Craft. n.d. <http://www.systems.textron.com/pdf/products/lcur_datasheet.pdf.> (19 November 2004).

Marine Corps Combat Development Command (MCCDC). Aviation Logistics Support Aboard Maritime Propositioning Force Future - MPF(F). Studies and Analysis Division, 21 October 2000.

Marine Corps Combat Development Command (MCCDC). "Baseline 2015 MEB." Concepts Branch Futures Division, 24 January 2003.

Marine Corps Combat Development Command (MCCDC). Expeditionary Maneuver Warfare Capability List. Quantico, VA: Operations Division, 16 June 2003.

Marine Corps Combat Development Command (MCCDC). MAGTF Planner's Reference Manual, MSTP Pamphlet 5-0.3. Quantico, VA: U.S. Marine Corps, Marine Air-Ground Task Force (MAGTF) Staff Training Program (MSTP) Center (C 467) MCCDC, 20 April 2001.

Marine Corps Combat Development Command (MCCDC). "MPF(F) 101." PowerPoint Brief. January 2003. <https://www.mccdc.usmc.mil/OpsDiv/Integration/logistics_integration.htm> (18 August 2004).

Marine Corps Requirements Oversight Council Executive Summary. "Maritime Prepositioning Force (Future) Capabilities Update and Center for Naval Analysis, Analysis of Alternatives In Progress Review, Update 3." 17 September 2003.

"Marine Expeditionary Unit." GlobalSecurity.org. 09 June 2003. <http://www.globalsecurity.org/military/agency/usmc/meu.htm> (20 November 2004).

McAllister, Keith R. MPF 2010 Ship-to-shore Movement and Sea-based Logistics Support, Volume 1: Report. Alexandria, VA: The CNA Corporation CRM 98-19, May 1998.

McCammon, Tom, Naval Surface Warfare Center, Carderock Division (NSWCCD). <MccammonTR@nswccd.navy.mil> "FW: Time Study Files." 16 September 2004. Office Communication (16 September 2004).

MilitaryCity.com. Military Operation Iraqi Freedom. n.d. <www.militarycity.com/valor/honor> (27 November 2004).

Mislick, Gregory. "Chapter 1: Cost Estimation Introduction and Overview" (online brief). August 2004. <http://diana.gl.nps.navy.mil/~gkmislic/oa4702> (01 September 2004). OA 4702 Cost Estimation of DoD Weapons Systems.

Mission Need Statement for Amphibious Assault Ship (LHA(R)). Washington, DC: Joint Requirements Oversight Council Memorandum (JROCM) 045-01, 05 March 2001.

Montgomery, Douglas C. Design and Analysis of Experiments. New York: John Wiley & Sons, 1976.

Moore, Charles W., Jr., Vice Admiral, U.S. Navy, and Edward Hanlon, Jr., Lieutenant General, U.S. Marine Corps. "Sea Basing: Operational Independence for a New Century." Proceedings. January 2003.

Mullen, Mike, Vice Admiral, U.S. Navy. "Sea Power 21: Global Concept of Operations." Proceedings. April 2003.

"MV-22 Osprey." NAVAIR. n.d. <http://pma275.navair.navy.mil/> (12 September 2004).

National Defense University, Joint Forces Staff College. The Joint Staff Officers Guide. Norfolk, VA: 2000.

National Military Strategy of the United States of America 2004. Chairman of the Joint Chiefs of Staff, 2004.

NATOPS Flight Manual Navy Model MV-22B Tiltrotor (Change 3, Preliminary). Naval Air Systems Command, NAVAIR A1-V22AB-NFM-000, 01 June 2000.

Naval Airship Association. Naval Airship Carrier Operations. 25 May 2001. <http://www.naval-airships.org/carrier.html> (23 November 2004).

Naval Aviation Maintenance Program (NAMP). Office of the Chief of Naval Operations, OPNAV Instruction 4790.15D, 26 June 2002.

Naval Cost Analysis Division (NCAD). Inflation indices, June 2004. <http://www.ncca.navy.mil/services/inflation.cfm> (15 August 2004).

Naval Cost Analysis Division (NCAD). Visibility and Management of Operating and Support Costs (VAMOSC). June 2004. <http://www.navyvamosc.com> (11 August 2004).

Naval Inventory Control Point. Doctrine for Logistic Support of Joint Operations, Joint Publication 4-0. 06 April 2000. <http://www.dtic.mil/doctrine/jel/new_pubs/jp4_0.pdf.> (15 October 2004).

Naval Research Advisory Committee (NRAC). "Sea Base CONOPS," Brief. April 2004.

Naval Research Advisory Committee (NRAC). "Sea Basing," (PowerPoint brief). August 2004.

Naval Studies Board, National Research Council. Naval Expeditionary Logistics: Enabling Operational Maneuver From the Sea. Washington, DC: National Academies Press, 1999.

Naval War College. Joint Military Operations course notes. Newport, RI: Naval War College Press, 2002.

Naval Warfare Development Command. "Seabasing SharePoint Site." Seabasing SharePoint Site. n.d. <https://nwcportal.nwc.navy.mil/nwdc/sea_basing/> (27 September 2004).

Naylor, Thomas H., editor. The Design of Computer Simulation Experiments. Durham, NC: Duke University Press, 1969.

Nelms, Douglas W. "A Bigger, Better Giant." Rotor & Wing. 01 November 2003. <http://defensedaily.com> (26 September 2004).

Olwell, David, and David Schrady. "OS 4580 Logistics Systems Analysis, Course Notes." Unpublished course notes, Naval Postgraduate School, Monterey, CA, September 2003.

"Operation Desert Storm." GlobalSecurity.org. 19 September 2004. <http://www.globalsecurity.org/military/ops/desert_storm-orbat.htm> (24 September 2004).

Operation of the Joint Capabilities Integration and Development System. Chairman of the Joint Chiefs of Staff Manual 3170.01A (CJCSM 3170.01A), 12 March 2004.

"Operational Rations: Meal, Ready-to-Eat (MRE)." Defense Logistics Agency (DLA). 25 August 2004. <http://www.dscp.dla.mil/subs/rations/meals/mres.htm> (05 October 2004).

"The Ordnance Shop Pallets." The Ordnance Shop. n.d. <http://www.ordnance.org/pallets.htm> (05 October 2004).

Perla, Peter O. The Art of Wargaming. Annapolis, MD: Naval Institute Press, 1990.

"PKT 7.62mm Coax MG." Sauron's Creations. n.d. <http://armor.kiev.ua/fofanov/Tanks/ARM/pkt.html> (05 October 2004).

PLWC: Premier Label Water Company. 30 August 2004. <www.plwc.net/faq.htm> (27 September 2004).

Program Executive Office (PEO) Ships. Maritime Prepositioning Force Future (MPF(F)). 18 October 2004. <http://peoships.crane.navy.mil/pms325/futureships/MPF(F)/MPF.htm> (20 October 2004).

Project Culebra: Seabased Combat Service Support for Ship-to-Objective-Maneuver. Alexandria, VA: The CNA Corporation, CRM 95-144, September 1995.

Quarterly Progress Report for Shipbuilding and Conversion. Department of the Navy, Naval Sea Systems Command (NAVSEA) 250-574, 01 July 2004.

Radio Frequency Identification (RFID) Policy. Memorandum, The Under Secretary of Defense, 30 July 2004.

Replenishment at Sea. Underway Replenishment Guide, Naval Warfare Publication 4-01.4, March 2001.

Rosen, Kevin C., Major, U.S. Marine Corps, EXPWARTRAGRUPAC. <kevin.rosen@navy.mil> "MEU Assault Timeline." 09 November 2004. Office communication (11 November 2004).

"RQ-2A Pioneer Unmanned Aerial Vehicle (UAV)." United States Navy: Fact File. 28 November 2000. <http://www.chinfo.navy.mil/navpalib/factfile/aircraft/air-uav.html> (14 September 2004).

"RQ-/MQ-1 Predator Unmanned Aerial Vehicle." Air Force Link. July 2001. <http://www.af.mil/factsheets/factsheet.asp?fsID=122> (12 September 2004).

SAR Program Acquisition Cost Summary. 30 September 2003. <http://www.defenselink.mil/news/Nov2003/d20031118sar> (18 October 2004).

Saunders, Stephen, Commodore, Royal Navy, editor. Jane's Fighting Ships 2003-2004. Alexandria, VA: Jane's Information Group, Inc., 2003.

Schmitt, John F. "A Practical Guide for Developing and Writing Military Concepts." Defense Adaptive Red Team (DART) Working Paper #02-4. McLean, VA: Hicks & Associates, Inc., December 2002.

Schrady, Professor David. Joint Sea Basing Logistics: Analysis Roadmap. Unpublished notes, Naval Postgraduate School, Monterey, CA, 30 April 2004.

Sea Base Logistical CONOPS, Draft. OPNAV N42, 04 June 2004.

Sea Basing Concept of Operations, Draft. Unpublished draft, Deputy Chief of Naval Operations for Warfare Requirements and Programs (OPNAV N7), 11 March 2004.

Sea Basing Concept of Operations (CONOPS), (DRAFT). Unpublished PowerPoint brief, OPNAV N703, 11 March 2004.

Selinger, Marc. "USAF to buy 'hundreds' of STOVL JSFs, Gen. Jumper says." Aerospace Daily & Defense Report (online journal). 14 September 2004. <http://www.aviationnow.com/avnow/news/channel_aerospacedaily_story.jsp?id=news/jsf09144.xml> (13 October 2004).

"SH-60 Lamps Mark III Seahawk." GlobalSecurity.org. 08 November 2001. <http://www.globalsecurity.org/military/systems/aircraft/sh-60.htm> (27 September 2004).

"SH-60 Seahawk." United States Navy: Fact File. 25 October 2003. <http://www.chinfo.navy.mil/navpalib/factfile/aircraft/air-sh60.html> (17 September 2004).

"Ship to Objective Maneuver (STOM)." Concept Paper, Commandant of the U.S. Marine Corps, 25 July 1997.

Sikorsky, A United Technologies Company. Heavy Lift Transport: Sikorsky CH-53E/S-80E Super Stallion. July 2000. <http://www.sikorsky.com/file/popup/1,185,00.pdf> (23 September 2004).

"SkyCat 1000." GlobalSecurity.org. 30 September 2004. <http://www.globalsecurity.org/military/systems/aircraft/skycat.htm> (03 November 2004).

"Skyship 600B Blimp/Airship Specifications." Global Skyship Industries, Inc. n.d. <http://www.globalskyships.com/gss2.htm> (04 December 2004).

Souders, Robert M., Suzanne Schulze, Yana Ginburg, and John Goetke. MPF(F) Analysis of Alternatives: Final Summary Report. Alexandria, VA: The CNA Corporation, CNR D0009814.A2/Final, April 2004.

"Standard NATO Steel Ammo Box, 7.62mm x 200." Flecktarn. Co. UK. n.d. <http://www.flecktarn.co.uk/spoab1ux.html> (08 December 2004).

Stewart, Jim, Captain, U.S. Navy, Frank Futcher, Lieutenant Commander, U.S. Navy, and Mr. Will Macht. "72nd Military Operations Research Society Symposium (MORSS), Seabasing Logistics Concept of Operations." Arlington, VA: CNO N421 (OPNAV N421), 1997-2004 Military Operations Research Society, 26 July 2004.

Stimpson, Daniel, Captain, U.S. Marine Corps. <dstimpso@nps.edu> "RE: CH-53 Transport Times." 01-02 November 2004. Office communication (02 November 2004).

Swartz, Karl L. Great Circle Mapper. n.d. <http://gc.kls2.com> (20 August 2004).

Systems Engineering and Integration Cohort Three (SEI-3). Expeditionary Warfare. Unpublished Research Paper, Naval Postgraduate School Technical Report, Monterey, CA: 2002.

"T-AOE(X) Replenishment Ship." GlobalSecurity.org. 18 August 2004. <http://www.globalsecurity.org/military/systems/ship/taoe-specs.htm> (05 October 2004).

Tiron, Roxana. "Navy Downsizing Could Weaken Marine Corps Expeditionary Posture." National Defense (online journal). August 2004. <http://www.nationaldefensemagazine.org/article.cfm?Id=1538> (05 November 2004).

Total Ship Systems Engineering Team. (2004). Joint ACCESS: A High-Speed Assault Connector for Amphibious Seabasing Operations and Joint Expeditionary Logistics. Monterey, CA: Naval Postgraduate School Technical Report, December 2004.

"UH-1 Iroquois (Huey)." GlobalSecurity.org. 30 September 2004. <http://www.globalsecurity.org/military/systems/aircraft/uh-1.htm> (02 October 2004).

"UH-1 Iroquois (Huey): Specifications." GlobalSecurity.org. 08 November 2001. <http://www.globalsecurity.org/military/systems/aircraft/uh-1-specs.htm> (26 September 2004).

"UH-1N Huey." Air Force Link. March 2003. <http://www.af.mil/factsheets/factsheet.asp?fsID=130> (17 September 2004).

Unit of Action Maneuver Battle Lab. The United States Army Objective Force Operational and Organizational Plan Maneuver Unit of Action. Fort Knox: Army Training and Doctrine Command (TRADOC) Pamphlet 525-3-90, Change 2, 30 June 2003.

Universal Joint Task List (UJTL). Chairman of the Joint Chiefs of Staff Manual 3500.04C (CJCSM 3500.04C), 01 July 2002.

Unmanned Aerial Vehicle (UAV) Planning Task Force: The UAV Roadmap 2002. 25 October 2001. <http://www.aviationnow.com/content/publication/awst/docs/exec_sum.pdf> (18 October 2004).

"Unmanned Aerial Vehicles UAVs." GlobalSecurity.org. 02 August 2004. <http://www.globalsecurity.org/intell/systems/uav-intro.htm> (02 October 2004).

U.S. Air Force. Global Vigilance, Reach and Power: America's Air Force Vision 2020.

U.S. Air Force. "U.S. Air Force Cost and Planning Factors." AFPAM 23-221, Fuel Logistics Planning, 01 May 98/AF1 65-503. September 2002.

U.S. Army Cost and Economic Analysis Center. Operating and Support Management Information System. 09 September 1999.

"V-22 Osprey." GlobalSecurity.org. 17 December 2003. <http://www.globalsecurity.org/military/systems/aircraft/v-22.htm> (05 October 2004).

"V-22A Osprey." United States Navy: Fact File. 10 May 1999. <http://www.chinfo.navy.mil/navpalib/factfile/aircraft/air-v22a.html> (17 September 2004).

Vance, Laurence M. "The U.S. Global Empire." LewRockwell.com. 16 March 2004. <www.lewrockwell.com/vance/vance8.html> (30 September 2003).

Vego, Milan N. Operational Warfare. Newport: Naval War College Press, 2000.

Wakefield, Timothy R., Master Sergeant AMC/A37VG. <Timothy.Wakefield@scott.af.mil> "Equipment Load Times." Office communication (October 2004).

Wikipedia. "Golden Hour." Wikimedia Foundation. June 2004. <http://www.wikipedia.org> (15 July 2004).

Worthington, Tom. USAV Spearhead (TSV-1X): High Speed U.S. Army Transport Ship. 15 October 2003. <http://www.tomw.net.au/2002/tsv1x.> (29 October 2004).

Wynn, Steven, Jeff Hough, and Howard Fireman. Rapid Strategic Lift Ship: Feasibility Study Report. Washington Navy Yard, DC: Naval Sea System Command (NAVSEA) Ser 05D/097, 29 September 2004.

Wynn, Steven. <WynnSB@NAVSEA.NAVY.MIL> "RSLS Questions." 05 November 2004. Office Communication (08 November 2004).

"XM1091 Fuel/Water Tanker." GlobalSecurity.org. 25 August 2004. <http://www.globalsecurity.org/military/systems/ground/m1091.htm> (05 October 2004).

Appendix B: Architecture Variable Specifications

The Systems Engineering Analysis Baseline Architecture System Evaluator Six (SEABASE-6) model uses parameters to represent the variables of the different architectures. These parameters are derived from research and analysis. The connector taxonomy decomposes into Inter-theatre, Intra-theatre, Sea Base, and Assault. Each of these categories decomposes into Surface and Air. In addition to connectors, Systems Engineering and Analysis Cohort Six (SEA-6) conducted an analysis of the variables associated with the time delays at the Sea Base and objective ashore for Inventory and Storage and Transfer mechanisms.

B.1 Surface Connectors

Parameters are derived for the following:

- Maritime Prepositioning Force, Future (MPF(F))
  - "Unconstrained-Size," Distributed Capability Ship
  - Afloat Forward Staging Base (AFSB)
  - Aviation Variant
- Rapid Strategic Lift Ship (RSLS)
- Joint ACCESS (High Speed Assault Connector)
- Landing Craft, Air Cushion (LCAC)
- Landing Craft Unit, Replacement (LCU(R))
- Heavy, Landing Craft, Air Cushion (HLCAC)

Payload capacities are determined for the surface connectors using standardized payloads.

Capacity for Food is based on the Joint Inter-Modal Container (JMIC)[303] of Meals-Ready-to-Eat (MRE)[304]. Each JMIC has a volume of 56.5 ft^3. Each case of MREs has a volume of 1.02 ft^3 and weighs 22 lbs; therefore, each JMIC can carry 1,218.8 lbs of MREs (56.2/1.02 ft^3 * 22 lbs). Each JMIC has a footprint of 16.5 ft^2.

Liquid Cargo Values for Fuel or Water are based on the capacity of the XM1091 Fuel/Water Tanker Truck. The XM1091 has a liquid capacity of 1,500 gallons. External dimensions of the XM1091[305] are 26.4' long x 8.8' wide, for a total footprint of 232.2 ft^2.

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[303] Linkowitz, Nick, HQMC/LPV, "Joint Inter-Modal Container (JMIC), 07 July 2004, pp. 4-6.
[304] "Meal, Ready-to-Eat (MRE)," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.dscp.dla.mil/subs/rations/meals/mres.htm.
[305] "XM1091 Truck," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ground/m1091.htm.

Class V Artillery cargo is based on the Light Weight 155 DPICM[306] round and charges loaded on standard military ammunition skids[307] within JMIC. Each JMIC has a footprint of 16.5 ft^2. Weight and area figures were calculated from a composition of three skids of DPICM, each carrying eight rounds and one skid of charges containing 24 charges called a JIMC quad. Each skid of DPICM weighs 798 lbs. Each skid of charges weighs 1,370 lbs.[308] Therefore, each group of 3 DPICM skids with 1 charge skid weighs 3,764 lbs and has a footprint of 66 ft^2.

Class V Small Arms cargo is based on the 7.62mm round loaded on standard military skids within JMIC. Each JMIC has a footprint of 16.5 ft^2. One box of 200 rounds of 7.62mm weighs[309] 16.8 lbs, with dimensions of 11 inches long x 7 inches high x 4 inches wide[310]. Each skid (40 in x 48 in) can hold 40 boxes per layer with five stacked layers, yielding 200 boxes of ammunition per skid. Therefore, each JMIC of 7.62mm weighs 200 boxes * 16.8 lbs = 3,360 lbs.

Reliability of Platforms (Mean Time Between Failure (MTBF)): For the full factorial experimental design, MTBF is set to 9,999 hrs (perfect reliability). This allows the effects of the external factors to show through. For the scenario simulation, the following equation is used to determine MTBF where A_∞ is asymptotic average availability, Mean Time to Repair (MTTR), and MLOG is logistics and administrative delay:

$$MTBF = \frac{A_\infty \times (MTTR + MLOG)}{(1 - A_\infty)}$$

B.1.1 "Unconstrained-Size," Distributed-Capability MPF(F) Parameter Analysis

This analysis assumes the selection of the Unconstrained Size, Distributed Capabilities design ship as detailed in the Center for Naval Analysis MPF(F) Analysis of Alternatives.[311]

Probability of Survival (P_S): For full factorial, 1.0 (no combat loss). This allows the effects of the external factors to show through. For the Southeast Asia Scenario values, see the analysis in the Scenario Description [Chapter 7].

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306 Marine Corps Combat Development Command, "MAGTF Planner's Reference Manual," April 2001, (UNITED STATES MARINE CORPS MSTP Center (C 54) MCCDC, Quantico, VA, 20 April 2001).
307 "Ordnance Pallets, Skids," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.ordnance.org/pallets.htm.
308 Marine Corps Combat Development Command, "MAGTF Planner's Reference Manual," April 2001, (UNITED STATES MARINE CORPS MSTP Center (C 54) MCCDC, Quantico, VA, 20 April 2001).
309 "Small Arms, 7.62mm Coax MG," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @http://armor/kiev/ua/fofanov/Tanks/ARM/pkt.html.
310 "7.62mm Ammo Box," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.surpluscenter.com.
311 Robert M. Sounders, Suzanne Schulze, Yana Ginburg, and John Goetke, "MPF(F) Analysis of Alternatives: Final Report," (Alexandria, VA: The CNA Corporation, CNR D00009814.A2/Final, April 2004), pp. 29-48.

Reliability (MTBF): For the scenario simulation the following values are used:

MTBF: For the purposes of this analysis, it is assumed that the MPF(F) never fails in a 40-day operation. MTBF = 9,999 hrs.

MTTR: Since it is assumed that MPF(F) does not fail, MTTR is not estimated.

Air Spots (I_A): Five per MPF(F) per Unconstrained Size, Distributed Capabilities design.[312] Two VERTREP spots due to pallet staging, sling space, etc.

Surface Spots (I_S): One per MPF(F) per Unconstrained Size, Distributed Capabilities design.[313]

Capacity (C): Approximated from full and lightship displacements of Unconstrained Size, Distributed Capabilities design.

82,850 tons (full) – 61,179 tons (light) = 21,671 tons
cargo weight capacity = 21,671 tons – 5,316 tons (JEB equipment) – 5,781 tons (cargo fuel) – 5,207 tons (own ship fuel)
= 5,367 tons
= 11,807,400 lbs

Class I Cargo is based on the JMIC of MREs.[314] Assuming a percentage of 26.5% (Combat Logistics Force T-AOE(X) distribution[315]), each MPF(F) can store 3,130,699 lbs of MREs.

Liquid Cargo Values for Class III and Water are based on the design capacity of the fuel/water holding tanks of MPF(F).[316]

Class V Artillery Cargo is based on the Light Weight 155 DPICM round and charges loaded on standard military ammunition skids[317] within a JMIC. Assuming an historical percentage[318] of 60.8%, each MPF(F) can carry 7,183,000 lbs of artillery.

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[312] Ibid., pp. 28-37.
[313] Ibid.
[314] "Meal, Ready-to-Eat (MRE)," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.dscp.dla.mil/subs/rations/meals/mres.htm.
[315] "T-AOE," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ship/taoe-specs.htm.
[316] Sounders et al., pp. 9-19.
[317] "Ammo Skids," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @Ammo Skids http://www.ordnance.org/pallets.htm.
[318] CAPT Jim Stewart, USN, LCDR Frank Futcher, USN, and Mr. Will Macht, "72nd Military Operations Research Society (MORS) Symposium, Seabasing Logistics Concept of Operations," (Arlington, VA: CNO N421 (OPNAV N421), 1997-2004 Military Operations Research Society, 26 July 2004.

Class V Small Arms Cargo is based on the 7.62mm round loaded on standard military skids within a JMIC. Assuming a historical percentage[319] of 12.6%, each MPF(F) can carry 1,493,800 lbs of small arms.

Speed (V): 20 kts listed as maximum intermittent speed, 17 kts listed as cruise.[320] Assume all transits at 17 kts.

Start Fuel (F_o): Designed for 1,687,200 gallons total self, not cargo fuel capacity.[321]

Fuel Usage Rate (FF): Derived from design starting fuel capacity and design endurance. Assuming a continuous transit at 17 kts for design endurance of 29.5 days (705.8 hrs): 1,687,200 gal/705.8 hrs = 2,383 gal/hrs = 140 gal/NM. During MODLOC, assume MPF(F) maintains station at approximately 7 kts. This is approximately 40% of cruise speed. Correlating this to fuel usage results in a MODLOC fuel usage rate of 56 gal/NM.

Range (R): Design range[322] of 12,000 NM at 17 kts.

Endurance (E): Design endurance of 29.5 days.[323]

B.1.2 AFSB Parameter Analysis

This analysis assumes the selection of the AFSB design ship as detailed in the CNA MPF(F) Analysis of Alternatives.[324]

Initial Quantity (N_o): The employment of High Speed Assault Connector Joint ACCESS reduced the number of MPF(F) ships required and Alternative Architecture I used 2 baseline MPF(Fs) and 2 AFSBs. The AFSB is chosen because it contains the required number of air spots to support sustainment operations.

Probability of Survival (P_S): For full factorial, 1.0 (no combat loss). This allows the effects of the external factors to show through. For the Southeast Asia Scenario values, see the analysis in the Scenario Description [Chapter 7].

Reliability (MTBF): For the scenario simulation, the following values are used:

MTBF: For the purposes of this analysis, it is assumed that the MPF(F) never fails in a 40-day operation. MTBF = 9,999 hrs.

319 Ibid.
320 Sounders et al., pp. 55-57.
321 Ibid., pp. 9-19.
322 Ibid., pp. 55-57.
323 Ibid., pp. 55-57.
324 Ibid., pp. 46-48.

MTTR: Since it is assumed that MPF(F) does not fail, MTTR is not estimated.

Air Spots (I_A): 11 per MPF(F) per AFSB design.[325] Seven are actually used in the modeling because the other four are required for parking spots.

Surface Spots (I_S): None per MPF(F) per AFSB design.[326]

Capacity (C): Approximated from full and lightship displacements of AFSB design.

Class I Cargo is based on the JMIC of the MRE.[327] Assuming a percentage of 26.5% (Combat Logistics Force AOE(X) distribution),[328] each MPF(F) can store 3,130,699 lbs of MREs.

Liquid Cargo Values for Class III and Water are based on the design capacity of the fuel/water holding tanks of the AFSB MPF(F).[329]

Class V Artillery Cargo is based on the Light Weight 155 DPICM round and charges loaded on standard military ammunition skids[330] within a JMIC. Assuming an historical percentage[331] of 60.8%, each MPF(F) can carry 7,183,000 lbs of artillery.

Class V Small Arms Cargo is based on the 7.62mm round loaded on standard military skids within a JMIC. Assuming a historical percentage[332] of 12.6%, each MPF(F) can carry 1,493,800 lbs of small arms.

Speed (V): 20 kts listed as maximum intermittent speed, 17 kts listed as cruise.[333] Assume all transits at 17 kts.

Start Fuel (F_o): Designed for 1,687,200 gallons total fuel capacity.[334]

Fuel Usage Rate (FF): Derived from design starting fuel capacity and design endurance. Assuming a continuous transit at 17 kts for design endurance of 29.5 days (705.8 hrs): 1,687,200 gallons/705.8 hrs = 2,383 gal/hr = 140 gal/NM. During MODLOC, assume MPF(F) maintains station at approximately 7 kts. This is

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325 Ibid., pp. 46-48.
326 Ibid., pp. 46-48.
327 "Meal, Ready-to-Eat (MRE)," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.dscp.dla.mil/subs/rations/meals/mres.htm.
328 "T-AOE," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ship/taoe-specs.htm.
329 Saunders et al., pp. 9-19.
330 "Ammo Skids," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.ordnance.org/pallets.htm.
331 Stewart et al., pp. 9-19.
332 Ibid.
333 Ibid., pp. 55-57.
334 Ibid., pp. 9-19.

approximately 40% of cruise speed. Correlating this to fuel usage results in a MODLOC fuel usage rate of 56 gal/NM.

Range (R): Design range[335] of 12,000 NM at 17 kts.

Endurance (E): Design endurance of 29.5 days.[336]

B.1.3 Aviation Variant Parameter Analysis

This analysis assumes the selection of the Unconstrained Size, Distributed Capabilities design ship as detailed in the CNA MPF(F) Analysis of Alternatives.[337] The design was modified by Design Team III with the removal the superstructure to provide a flat carrier like deck with out an island.

Probability of Survival (P_S): For full factorial, 1.0 (no combat loss). This allows the effects of the external factors to show through. For the Southeast Asia Scenario values, see the analysis in the Scenario Description [Chapter 7].

Reliability (MTBF): For the scenario simulation the following values are used:

> **MTBF:** For the purposes of this analysis, it is assumed that the MPF(F) never fails in a 40-day operation. MTBF = 9,999 hrs.
>
> **MTTR:** Since it is assumed that MPFF does not fail, MTTR is not estimated.

Air Spots (I_A): Five per MPF(F) per Unconstrained Size, Distributed Capabilities design.[338]

Surface Spots (I_S): 0.

Capacity (C): Approximated from full and lightship displacements of Unconstrained Size, Distributed Capabilities design.

82,850 tons (full) – 61,179 tons (light) = 21,671 tons. 21,671 tons – 5,316 tons (equipment) – 5,781 tons (cargo fuel) – 5,207 tons (own ship fuel) = 5,367 tons cargo weight capacity = 11,807,400 lbs.

> **Capacity for Class I Cargo** is based on the JMIC of MREs.[339] Assuming a percentage of 26.5% (Combat Logistics Force AOE(X) distribution),[340] each MPF(F) can store 3,130,699 lbs of MREs.

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[335] Ibid., pp. 55-57.
[336] Ibid.
[337] Ibid., pp. 28-38.
[338] Ibid., pp. 20-28.

Liquid Cargo Values for Class III and Water are based on the design capacity of the fuel/water holding tanks of MPF(F).[341]

Class V Artillery Cargo is based on the Light Weight 155 DPICM round and charges loaded on standard military ammunition skids[342] within JMIC. Assuming an historical percentage[343] of 60.8%, each MPF(F) can carry 7,183,000 lbs of artillery.

Class V Small Arms Cargo is based on the 7.62mm round loaded on standard military skids within JMIC. Assuming a historical percentage[344] of 12.6%, each MPF(F) can carry 1,493,800 lbs of small arms.

Speed (V): Thirty kts as maximum intermittent speed; 20 kts listed as cruise.[345] Assume all transits at 17 kts.

Start Fuel (F_o): Designed for 1,687,200 gallons total fuel capacity.[346]

Fuel Usage Rate (FF): Derived from design starting fuel capacity and design endurance. Assuming a continuous transit at 17 kts for design endurance of 29.5 days (705.8 hrs): 1,687,200 gal/705.8 hrs = 2,383 gal/hr = 140 gal/NM. During MODLOC, assume the MPF(F) ship maintains station at approximately 7 kts. This is approximately 40% of cruise speed. Correlating this to fuel usage results in a MODLOC fuel usage rate of 56 gal/NM.

Range (R): Design range[347] of 12,000 NM at 17 kts.

Endurance (E): Design endurance of 29.5 days.[348]

B.1.4 RSLS Parameter Analysis

This analysis assumes the use of the Naval Sea Systems Command (NAVSEA) Hangar Version of the RSLS.[349] All numbers and calculations below come from the NAVSEA RSLS Feasibility Study report.

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339 "Meal, Ready-to-Eat (MRE)," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.dscp.dla.mil/subs/rations/meals/mres.htm.
340 "T-AOE," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ship/taoe-specs.htm.
341 Saunders et al., pp. 9-19.
342 "Ammo Skids," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.ordnance.org/pallets.htm.
343 Stewart et al., pp. 9-19.
344 Ibid.
345 Saunders et al., pp. 55-57.
346 Ibid., pp. 9-19.
347 Ibid., pp. 55-57.
348 Ibid., pp. 9-19.

Probability of Survival (P_S): For full factorial, 1.0 (no combat loss). This allows the effects of the external factors to show through. For the Southeast Asia Scenario values, see the analysis in the Scenario Description [Chapter 7].

Reliability (MTBF): For the scenario simulation the following values are used:

> **MTBF:** For the purposes of this analysis, it is assumed that the MPF(F) never fails in a 40-day operation. MTBF = 9,999 hrs.
>
> **MTTR:** Since it is assumed that MPF(F) does not fail, MTTR is not estimated.

Air Spots (I_A): 2.

Surface Spots (I_S): Not applicable.

Capacity (C): Approximated from full and lightship displacements of the RSLS Hangar version design: 32,219 tons (full) – 19,706 tons (light) = 12,513 tons. 12,513 tons – 405 tons (cargo fuel) – 7,782 tons (own ship fuel) = 4,326 tons max cargo/containerized weight capacity = 8,652,000 lbs. The RSLS has a container capacity of 250 TEUs; each TEU has a volume of 34 cu meters or 1,200 cu ft. Total RSLS TEU volume: 250 TEU X 1,200 cu ft/TEU = 326,400 cu ft. Each JMIC has a volume of 56.5 cu ft. The number of equivalent JMICs that can fit into this RSLSs TEU volume (4 holds): 300,000 cu ft/ 56.5 cu ft = 5,309 JMICs. Capacities to be carried are calculated based on one commodity at a time; as a mix of commodities will need to be carried for the RSLS (as a CLF ship) to properly replenish the Sea Base, capacity ratios of food versus water versus fuel, will have to be determined by planners at a later time.

> **Capacity for Class I Cargo Food** is based on the JMIC of MRE.[350] Based on an RSLS hold capacity of 5,309 JMICs, each RSLS can store 6,470,609 lbs of MREs: 5,309 JMICs X 1,219 lbs MREs/JMIC = 6,471,671 lbs; 1 DOS for food = 27,113 lbs; total RSLS MRE DOS: (1 DOS/27,113 lbs) = 6,471,671 lbs = 238 DOS.
>
> **Liquid Cargo Values for Class III Fuel** is based on RSLS internal cargo JP5 stowage tank capacity of 405 Short Tons = 810,000 lbs = 119,118 gal; as 1 DOS for fuel = 134,000 gal, the RSLS falls short of the JEB daily fuel replenishment requirement.
>
> **Liquid Cargo Values for Class I Water** is based on standard 40 in X 48 in pallet size of cases of 20 oz bottles of drinking water. If max cargo weight is

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349 Naval Sea Systems Command, "Rapid Strategic Lift Ship (RSLS) No-Hangar Version" chapter, in Rapid Strategic Lift Ship Feasibility Study, [NAVSEA report /database online] (Report 05D/097, 29 September 2004, [cited 07 December 2004]), pp. 20-29.

350 "Meal, Ready-to-Eat (MRE)," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.dscp.dla.mil/subs/rations/meals/mres.htm.

8,652,000 lbs, and 1 water DOS = 34,013 gal, then number of water DOS that the RSLS can carry: 8,652,000 lbs X 1 ton/2,000 lbs = 4,326 tons X 270 gal/ton = 1,168,020 gal maximum capacity/34,013 gal = 34 DOS X 34,013 gal/1 DOS = 1,156,442 gal.

Class V Artillery Cargo is based on the Light Weight 155 DPICM round and charges loaded on standard military ammunition skids[351] within JMIC. Given the RSLS hold capacity of 5,309 JMICs or 1,327 JMIC quads. Therefore, each RSLS can store 4,994,828 lbs of artillery cargo: 5,309 JMICs /4=1,327 JMIC quads X 3,764 lbs = 4,994,828 lbs.

Class V Small Arms Cargo is based on the 7.62mm round loaded on standard military skids within JMIC. Given the RSLS hold capacity of 5,309 JMICs, each RSLS can store 17,838,240 lbs of small arms ammunition, which is more than the ship can carry. So, given a maximum capacity of 8,652,000 lbs/3,360 lbs = 2,575 JMICs of small arms cargo or 8,652,000 lbs.

Speed (V): 36; assume all transits at 36 kts.

Start Fuel (F_o): Designed for 2,167,053 gallons total fuel capacity (7,782 tons X 278.47 gal/ton = 2,167,053 gal).

Fuel Usage Rate (FF): Derived from design starting fuel capacity and design endurance. Assuming a continuous transit at 36 kts for design endurance of 9.25 days (222 hrs): 2,167,053 gal/222 hrs = 9,761 gal/hr = 286 gal/NM.

Range (R): Design range of 8,000 NM at 36 kts.

Endurance (E): Design endurance of 9.25 days = 222 hrs.

B.1.5 Joint ACCESS Parameter Analysis

This analysis assumes that Total Ships Systems Engineering (TSSE) design for the Joint ACCESS [Appendix F].

Probability of Survival (P_S): For full factorial, 1.0 (no combat loss). This allows the effects of the external factors to show through. For the Southeast Asia Scenario values, see the analysis in the Scenario Description [Chapter 7].

Reliability (MTBF): For the scenario simulation, the following values are used:

[351] "Ammo Skids," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ Ammo Skids http://www.ordnance.org/pallets.htm.

MTBF: For the purposes of this analysis, it is assumed that the MPF(F) never fails in a 40-day operation. MTBF = 9,999 hrs.

MTTR: Since it is assumed that MPF(F) does not fail, MTTR is not estimated.

Air Spots (I_A): One air spot capable of supporting SH-60R, MV-22 and CH-53E.

Surface Spots (I_S): Not applicable.

Capacity (C): The Joint ACCESS maximum afloat weight is assumed to be 1,792,000 lbs. Joint ACCESS design cargo area dimensions = 21,958 ft^2.

Food. Each Joint ACCESS can carry 1,330 JMICs of MREs single stacked yielding 1,621,270 lbs. Partial Double stacked JMIC yields 1,791,930 lbs.

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 1,791,930 lbs/1,792,000 lbs = 99%
  Limit Weight = 1,792,000 lbs
  Actual Weight = 1,791,930 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 21,495 ft^2/ 21,958 ft^2 = 97.8%
  Area Limit = 21,958 ft^2
  Area Actual = 1,330 JMIC * 16.5 ft^2 = 21,495 ft^2

Fuel or Water. 1,792,000 lbs/24,194 lbs = 74 XM1091 per Joint ACCESS, therefore, 74*1,500 gallons = 111,000 gallons.

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 1,790,356 lbs/1,792,000 lbs = 99.9%
  Limit Weight = 1,792,000 lbs
  Actual Weight = 24,194 lbs per XM1091 * 74 XM1091 = 1,790,356 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 17,182.8 ft^2/ 21,958 ft^2 = 78%
  Area Limit = 21,958 ft^2
  Area Actual = 232.2 ft^2 per XM1091 * 74 XM1091 = 17,182.8 ft^2

Ammunition Artillery. Each Joint ACCESS can carry 332 JMIC quads single stacked yielding 1,249,648 lbs. Partial Double stacked yields 1,791,664 lbs.

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 1,791,664 lbs/1,792,000 lbs = 99.9%
  Limit Weight = 1,792,000 lbs
  Actual Weight = 1,791,664 lbs

- **Area Fraction (A%)** = Area Actual/Area Limit = 21,912 ft^2/ 21,958 ft^2 = 99.7%
  Area Limit = 21,958 ft^2
  Area Actual = 21,958 ft^2/66 ft^2 per JMIC = 332 JMIC quad = 21,912 ft^2 (332 * 66)

Ammunition Small Arms. By area each Joint ACCESS can carry 1,330 JMICs (21,958ft^2/16.5 ft^2) yielding 4,468,800 lbs; however, this exceeds the weight limit of the Joint ACCESS. Therefore, assuming Joint ACCESS is loaded below maximum weight with 7.62mm ammunition (1,792,000 lbs), and then the Joint ACCESS could carry 533 JMICs yielding 1,790,880 lbs of 7.62mm ammunition (533 * 3,360 lbs).

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 1,790,880 lbs/1,792,000 lbs = 99.9%
  Limit Weight = 1,792,000 lbs
  Actual Weight = 1,790,880 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 8,794.5 ft^2/ 21,958 ft^2 = 40%
  Area Limit = 21,958 ft^2
  Area Actual = 16.5 ft^2 per JMIC * 533 JMIC = 8,794.5 ft^2

Troops. The Joint ACCESS can carry 260 combat troops.

Speed (V): 43 kts listed as maximum intermittent speed, 34 kts listed as cruise.

Start Fuel (F_o): Designed for 158,500 gallons total fuel capacity.

Fuel Usage Rate (FF): Derived from design starting fuel capacity minus remaining fuel and design endurance. Assuming a continuous transit at 34 kts for design endurance of 2,636 NM. (158,500–26,417 gallons) 132,083 gal/2,636 NM = 0.019 gal/NM.

Range (R): Design range of 2636 NM averaging 34 kts.

Endurance (E): Design endurance of 2,636 NM at 34 kts and 1,660 NM at 43 kts. Endurance is calculated with a remaining fuel capacity of 26,417 gallons.

B.1.6 LCAC Parameter Analysis

Information is from www.globalsecurity.org Website, unless otherwise noted.

Probability of Survival (P_S): For full factorial, 1.0 (no combat loss). This allows the effects of the external factors to show through. For the Southeast Asia Scenario values, see the analysis in the Scenario Description [Chapter 7].

Availability is modeled using estimated reliabilities and maintainabilities. See Reliability, Availability, and Maintainability Analysis [Chapter 6].

Reliability (MTBF): For the scenario simulation the following values are used:

MTBF = (Ao*(MTTR + MLOG))/(1 – Ao)

Assuming that:

MTTR = 16 hrs (based on fleet experience)

MLOG = 1.333 hrs

then

MTBF = (Ao*(MTTR + MLOG))/(1 – Ao)

= (0.6(16 hrs + 1.33 hrs))/(1-0.6)

≈ 26 hrs between failures

Air Spots (I_A): None.

Surface Spots (I_S): None.

Capacity (C): LCAC cargo area dimensions, 1,809 sq ft. Weight Capacity = 120,000 lbs.[352]

Food. Each LCAC can carry 98 JMICs of MREs single stacked yielding 119,442.4 lbs. (120,000 lbs/1,218.8 lbs/JMIC (MRE) = 98 JMIC MREs) (1,218.8 lbs * 98 JMIC MRE = 119,442.4 lbs JMIC MRE).

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 119,442 lbs/120,000 lbs = 99.5%
  Limit Weight = 120,000 lbs
  Actual Weight = 119,442 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 1,617 ft^2/ 1,809 ft^2 = 89%
  Area Limit = 1,809 ft^2
  Area Actual = 98 JMIC * 16.5 ft^2 = 1,617 ft^2

352 "Landing Craft, Air Cushion (LCAC)," (17 July 2004 [cited 02 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ship/lcac.htm.

Water. 1,809 ft^2/232.2 ft^2 = 7 XM1091 per LCAC, but the XM1091 has a total weight of 24,194 lbs and weight capacity of LCAC is 120,000; therefore, 120,000/24,194 = 4 XM1091 *1,500 gallons per XM1091 = 6,000 gallons.

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 96,776 lbs/120,000 lbs = 80.6%
  Limit Weight = 120,000 lbs
  Actual Weight = 24,194 lbs per XM1091 * 4 XM1091 = 96,776 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 928.8 ft^2/ 1,809 ft^2 = 51%
  Area Limit = 1,809 ft^2
  Area Actual = 232.2 ft^2 per XM1091 * 4 XM1091 = 928.8 ft^2

Artillery. Each LCAC can carry 27 JMIC quads single stacked yielding 101,628 lbs. Partial double stacked yields 116,684 lbs (31 JMIC).

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 116,684 lbs/120,000 lbs = 97%
  Limit Weight = 120,000 lbs
  Actual Weight = 116,684 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 1,782 ft^2/1,809 ft^2 = 98.5%
  Area Limit = 1,809 ft^2
  Area Actual = 1,809 ft^2/66 ft2 per JMIC = 27 JMIC quad = 1,782 ft^2 (27 * 66)

Small Arms. LCAC can carry 35 JMICs yielding 117,600 lbs of 7.62mm ammunition (35 * 3,360 lbs).

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 117,600 lbs/120,000 lbs = 98%
  Limit Weight = 120,000 lbs
  Actual Weight = 117,600 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 577.5 ft^2/1,809 ft^2 = 31.9%
  Area Limit = 1,809 ft^2
  Area Actual = 16.5 ft^2 per JMIC * 35 JMIC = 577.5 ft^2

Supply Capacity Distribution: Based on operational and commercial experience, it is assumed that there is some variability on the loads carried by the assault connectors. Specifically, each connector is assumed carry, on average, 85% of its maximum capacity (calculated in each platform write up). It was further assumed that they would carry less than 95% of their capacity 95% of the time, giving a standard deviation of 5%. Therefore, the values listed for supply capacities are derived by:

- Calculating the maximum capacity of that particular supply class given palletized packaging.
- Ammunition: the average of small arms (7.62mm) and artillery (155 DPICM) was used to calculate the distribution.
- Multiplying that maximum by 0.85 to get the mean and 0.05 to get the standard deviation.
- Ammunition: Norm (99,751, 5,657); Food: Norm (101,526, 5,972); Water: Norm (11,475, 675).

Speed (V): 40 kts with payload, sea state 2. Above sea state 2 planning speed is 25 kts fully loaded. Empty without payload speed is 40 kts sea state 2 and below and 35 kts above sea state 2.

Start Fuel (F_o): 5,000 gals.

Fuel Usage Rate (FF): $SS \leq 2$ = 1000 gallons/hr at (40kts) = 25 gal/NM.
$SS \leq 2$ = Range of LCAC empty is 300 NM at 35 kts. Endurance = 300 NM/35 kts = 8.5 hrs
5,000 gals/8.5 hrs = 588 gal/hr at (35 kts) empty = 16.8 gal/NM.
$SS \geq 3$ = Planning speed is 25 kts. Assuming LCAC can travel fully loaded 200 NM at 25 kts gives the following fuel usage rate:
200 NM/25 kts = 8 hrs
5,000 gal/8 hrs = 625 gal/hr at (25 kts) = 25 gal/NM

Range:
$SS \leq 2$
R = 200 NM at 40 kts Fully Loaded
R = 300 NM at 35 kts Empty
$SS \geq 3$
R = 300 NM at 25 kts Fully loaded

Endurance (E): 5000 gals/1000 gal/hr = 5 hrs at 40 kts fully loaded
300 NM/35 kts = 8.5 hrs empty
200 NM/25 kts = 8 hrs (assuming LCAC can has range of 200 NM fully loaded at 25 kts)

B.1.7 LCU(R) Parameter Analysis

This analysis assumes that TEXTRON Marine and Land Systems Planning Landing Craft design for the LCU(R).[353]

[353] "Landing Craft Utility (LCU)," (18 August 2004 [cited]); available from the World Wide Web @ http://www.tmls.textron.com.

Probability of Survival (P_S): For full factorial, 1.0 (no combat loss). This allows the effects of the external factors to show through. For the Southeast Asia Scenario values, see the analysis in the Scenario Description [Chapter 7].

Reliability (MTBF): For the scenario simulation the following values are used:

The reliability of LCU(R) was calculated by assuming an improvement of 15% over the LCAC since the system is completely redesigned from the LCU 1600 class and LCAC was a better analogous system to the LCU(R). Automation and simplicity of design features will make LCU(R) a craft that will be simple, rugged, and reliable and designed with low maintenance features to improve availability.[354]

This 15% improvement is expressed as a 15% increase in MTBF

$$MTBF_{LCU\text{-}R} = (1.15)^* \, MTBF_{LCAC}$$

$$= (1.15)^*(26 \text{ hrs})$$

$$= 29.9 \approx 30 \text{ hrs}$$

Air Spots (I_A): Not applicable for a surface assault connector.

Surface Spots (I_S): Not applicable for a surface assault connector.

Capacity (C): The LCU(R) maximum afloat weight is assumed to be 495,000 lbs.[355] LCU(R) design cargo area dimensions,[356] 106' long x 26.4' wide = 2,800 ft^2.

Food: Each LCU(R) can carry 169 JMICs of MREs single stacked yielding 205,977 lbs. Double stacked JMIC yields 411,954 lbs.

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 411,954 lbs/495,000 lbs = 83%
  Limit Weight = 495,000 lbs
  Actual Weight = 411,954 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 2,788.5 ft^2/2,800 ft^2 = 99.5%
  Area Limit = 2,800 ft^2
  Area Actual = 169 JMIC * 16.5 ft^2 = 2,788.5 ft^2

[354] Global Security.org, "Landing Craft Utility, Replacement LCU(R)," (18 August 2004) available on the Web @ http://www.globalsecurity.org/military/systems/ship/lcu-x.htm, (cited 04 October, 2004).
[355] "Landing Craft Utility (LCU)," (18 August 2004 [cited]); available from the World Wide Web @ http://www.tmls.textron.com.
[356] Ibid.

Fuel or Water. 2,800 ft^2/232.2 ft^2 = 12.1 XM1091 per LCU(R); therefore, 12*1,500 gallons = 18,000 gallons.

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 290,328 lbs/495,000 lbs = 58.6%
  Limit Weight = 495,000 lbs
  Actual Weight = 24,194 lbs per XM1091 * 12 XM1091 = 290,328 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 2,784.4 ft^2/ 2,800 ft^2 = 99.5%
  Area Limit = 2,800 ft^2
  Area Actual = 232.2 ft^2 per XM1091 * 12 XM1091 = 2,784.4 ft^2

Ammunition Artillery. Each LCU(R) can carry 42 JMIC quads single stacked yielding 158,088 lbs. Double stacked yields 316,176 lbs.

- **Weight Fraction (W%) =** Actual Weight / Limit Weight = 316,176 lbs/495,000 lbs = 63.8%
  Limit Weight = 495,000 lbs
  Actual Weight = 316,176 lbs

- **Area Fraction (A%)** = Area Actual/Area Limit = 2,772 ft^2/2,800 ft^2 = 99%
  Area Limit = 2,800 ft^2
  Area Actual = 2,800 ft^2/66 ft^2 per JMIC = 42 JMIC quad = 2,772 ft^2 (42 * 66)

Ammunition Small Arms. By area each LCU(R) can carry 169 JMICs (2,800 ft^2/16.5 ft^2) yielding 567,840 lbs; however, this exceeds the weight limit of the LCU(R). Therefore, assuming LCU(R) is loaded below maximum weight with 7.62mm ammunition (495,000 lbs), and then the LCU(R) could carry 147 JMICs yielding 493,920 lbs of 7.62mm ammunition (147 * 3,360 lbs).

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 493,920 lbs/495,000 lbs = 99%
  Limit Weight = 495,000 lbs
  Actual Weight = 493,920 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 2,425.5 ft^2/2,800 ft^2 = 86.6%
  Area Limit = 2,800 ft^2
  Area Actual = 16.5 ft^2 per JMIC * 147 JMIC = 2,425.5 ft^2

Supply Capacity Distribution: Based on operational and commercial experience, it is assumed that there is some variability on the loads carried by the assault connectors. Specifically, each connector is assumed carry, on average, 85% of its maximum capacity (calculated in each platform write up). It was further assumed that they would carry less

than 95% of their capacity 95% of the time, giving a standard deviation of 5%. So, the values listed for supply capacities are derived by:

- Calculating the maximum capacity of that particular supply class given palletized packaging.
- Ammunition: the average of small arms (7.62mm) and artillery (155 DPICM) was used to calculate the distribution.
- Multiplying that maximum by 0.85 to get the mean and 0.05 to get the standard deviation.
- Ammunition: Norm(405,048, 20,253); Food: Norm(350,101, 20,597); Water: Norm(47,736, 2,808).

Troops: The LCU(R) is not designed to transport personnel aside from those in the transported vehicles.

Speed (V): 36 kts listed as maximum intermittent speed, 30 kts listed as cruise.[357] Assume all loads moved at 30 kts. Speed in sea state 2 = 30 kts, sea state 3 = 25 and sea state 4 = 0.

Start Fuel (F_0): Designed for 17,000 gallons total fuel capacity.[358] Assault fuel load reduced to 4,250 gallons.

Fuel Usage Rate (FF): Derived from design starting fuel capacity and design endurance. Assuming a continuous transit at 30 kts for design endurance of 10 days (240 hrs): 17,000 gal/240 hrs = 70.8 gal/hr = 2.36 gal/NM.

Range (R): Design range[359] of 900 NM averaging 28 kts.

Endurance (E): Design endurance of 10 days.[360]

B.1.8 HLCAC Parameter Analysis

Most information came from the Global Security Website, Globalsecurity.org, unless otherwise noted.

Probability of Survival (P_S): For full factorial, 1.0 (no combat loss). This allows the effects of the external factors to show through. For the Southeast Asia Scenario values, see the analysis in the Scenario Description [Chapter 7].

Reliability (MTBF): For the scenario simulation the following values are used:

[357] Ibid.
[358] Ibid.
[359] Ibid.
[360] Ibid.

MTBF = (Ao*(MTTR + MLOG))/ (1 – Ao)

Assuming that:

MTTR = 16 hrs (based on fleet experience)

MLOG = 1.333 hrs

then

MTBF = (Ao*(MTTR + MLOG))/(1 – Ao)

= (0.6(16 hrs + 1.33 hrs))/(1-0.6)

≈ 26 hrs between failures

Air Spots (I_A): None.

Surface Spots (I_S): None.

Weight Capacity (C): HLCAC cargo area dimension, 2,406 sq ft. Weight Capacity = 288,000 lbs.[361]

Food cargo is based on the JMIC[362] of MRE.[363]. The HLCAC is area limited. If enough area was available, based on payload, the HLCAC could carry 236 JMICs of MREs single stacked (288,000 lbs/1,218.8 lbs/JMIC (MRE) = 236 JMIC MREs). Due to area limitation, each HLCAC can carry 145 JMICs (2,406 ft^2/16.5 ft^2 = 145 JMICs) (145 JMIC MREs*1,218.8 lbs = 176,682.5 lbs JMIC MRE).

- **Weight Fraction (W%) =** Actual Weight/Limit Weight =
  176,682.5 lbs/288,000 lbs = 61.3%
  Limit Weight = 288,000 lbs
  Actual Weight = 176,682.5 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit =
  2,393 ft^2/2,406 ft^2 = 99.5%
  Area Limit = 2,406 ft^2
  Area Actual = 145 JMIC * 16.5 ft^2 = 2,393 ft^2

Water: To represent the least efficient (worst case) for water, it was assumed that water was transported as commercial bottled water. Representative bottled water numbers were

[361] Ibid.
[362] Linkowitz, Nick, HQMC/LPV, "Joint Inter-Modal Container (JMIC), 07 July 2004, pp. 4-6.
[363] "Meal, Ready-to-Eat (MRE)," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.dscp.dla.mil/subs/rations/meals/mres.htm.

obtained from the Web[364]. From that data, it seemed that the 20 oz. bottles were the best choice (20 oz. per bottle, 24 bottles per case, 33 lbs per case, 72 cases per pallet).

For the purpose of water, all water was considered palletized. The "standard" pallet size was borrowed from industry and from the JMIC program. This size is 48" x 40" x 39" (length, width, height) which translates to 4.00' x 3.33' x 3.25'. These give a pallet footprint of 13.3 ft^2 and a volume of 43.3 ft^3. The pallets are assumed to be stacked two high. All of the following calculations were based on this standard pallet size. HLCAC has an area of 2,406 ft^2; therefore, it can carry (2,406 ft^2/13.3 ft^2) = 180 pallets single stacked and 360 double stacked.

Water pallet weight = (22 lbs/case)*(72 cases/pallet) = 2,376 lbs/pallet

Pallets = round down ((288,000 lbs/HLCAC)/(2,376 lbs/pallet)) = 121 pallets/HLCAC

Weight = (121 pallets)*(2,376 lbs/pallet) = 287,496 lbs/HLCAC

Gallons = (20 oz/bottle)*(0.00781 gal/oz.)*(24 bottles/case)*(72 cases/pallet) = 270 gallons/pallet

(121 pallets/ HLCAC*(270 gal/pallet) = 32,670 gal/HLCAC

Weight fraction (W%) = Actual/limit = (287,496 lbs)/(288,000 lbs) = 99.8%
Area = (121 pallets)*(13.3 ft^2) = 1609.3 ft^2; Area Fraction = (A%) = (1,609.3 ft^2)/(2,406 ft^2) = 66.9%

Fuel is based on the capacity of the XM1091 Fuel/Water Tanker Truck. XM1091 has a liquid capacity of 1,500 gallons. External dimensions of the XM1091[365] are 26.4 ft long x 8.8 ft wide for a total footprint of 232.2 ft^2. 2,406 ft^2/232.2 ft^2 = 10 XM1091 per HLCAC. 10 XM1091 *1,500 gallons per XM1091 = 15,000 gallons.

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 241,940 lbs/288,000 lbs = 84%
  Limit Weight = 288,000 lbs
  Actual Weight = 24,194 lbs per XM1091 * 10 XM1091 = 241,940 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 2,322 ft^2/2,406 ft^2 = 96.5%
  Area Limit = 2,406 ft^2
  Area Actual = 232.2 ft^2 per XM1091 * 10 XM1091 = 2,322 ft^2

[364] "Bottled Water," (30 August 2004 [cited 05 October 2004]); available from the World Wide Web @ www.plwc.net/faq.htm.
[365] "XM1091 Truck," (25 September 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.globalsecurity.org/military/systems/ground/m1091.htm.

Ammunition Artillery cargo is based on the Light Weight 155 DPICM[366] round and charges loaded on standard military ammunition skids[367] within JMIC. Each HLCAC can carry 36 JMIC quads single stacked yielding 135,504 lbs. Double stacked yields 271,008 lbs (72 JMIC).

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 271,008 lbs/288,000 lbs = 94.1%
  Limit Weight = 288,000 lbs
  Actual Weight = 271,008 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 2,376 ft^2/2,406 ft^2 = 98.7%
  Area Limit = 2,406 ft^2
  Area Actual = 2,406 ft^2/66 ft^2 per JMIC = 36 JMIC quad = 2,376 ft^2 (36 * 66)

Ammunition Small Arms cargo is based on the 7.62mm round loaded on standard military skids within JMIC. HLCAC can carry 85 JMICs yielding 285,600 lbs of 7.62mm ammunition (85 * 3,360 lbs).

- **Weight Fraction (W%) =** Actual Weight/Limit Weight = 285,600 lbs/288,000 lbs = 99%
  Limit Weight = 288,000 lbs
  Actual Weight = 285,600 lbs
- **Area Fraction (A%)** = Area Actual/Area Limit = 1,402.5 ft^2/2,406 ft^2 = 58.3%
  Area Limit = 2,406 ft^2
  Area Actual = 16.5 ft^2 per JMIC * 85 JMIC = 1,402.5 ft^2

Supply Capacity Distribution: Based on operational and commercial experience, it is assumed that there is some variability on the loads carried by the assault connectors. Specifically, each connector is assumed carry, on average, 85% of its maximum capacity (calculated in each platform write up). It was further assumed that they would carry less than 95% of their capacity 95% of the time, giving a standard deviation of 5%. So, the values listed for supply capacities are derived by:

- Calculating the maximum capacity of that particular supply class given palletized packaging.
- Ammunition: the average of small arms (7.62mm) and artillery (155 DPICM) was used to calculate the distribution.
- Multiplying that maximum by 0.85 to get the mean and 0.05 to get the standard deviation.

[366] Marine Corps Combat Development Command, "MAGTF Planner's Reference Manual," April 2001, (UNITED STATES MARINE CORPS MSTP Center (C 54) MCCDC, Quantico, VA, 20 April 2001).
[367] "Ammo Skids," (25 August 2004 [cited 05 October 2004]); available from the World Wide Web @ http://www.ordnance.org/pallets.htm.

- Ammunition: Norm(230,356, 13,550); Food: Norm(150,180, 8,834); Water: Norm(244,371, 14,374); Fuel: Norm(205,649, 12,097); Small arms: Norm(242,760, 14,280).

Speed (V): 40 kts kts with payload, sea state 2. Above sea state 2 planning speed is 25 kts fully loaded.

Speed Distribution: Based on operational experience and the literature, an average speed was estimated. For the surface craft, 2.5 kts was considered the standard deviation based on normal craft operator deviations.

- SS $\leq$ 2: Norm(40, 2.5) fully loaded/empty
- SS $\geq$ 3: Norm(25, 2.5) fully loaded
- SS $\geq$ 3: Norm(35, 2.5) empty

Start Fuel (F_o): 5,000 gals.

Fuel Usage Rate (FF): SS$\leq$2 = 1,000 gallons/hr at (40 kts) = 25 gal/NM.
SS$\leq$2 = Range of HLCAC empty is 300 NM at 35 kts. Endurance = 300 NM/35 kts = 8.5 hrs
5,000 gals/8.5 hrs = 588 gal/hr at (35 kts) empty = 16.8 gal/NM.
SS $\geq$ 3 = Planning speed is 25 kts. Assuming HLCAC can travel fully loaded 200 NM at 25 kts gives the following fuel usage rate:
200 NM/25 kts = 8 hrs
5,000 gal/8 hrs = 625 gal/hr at (25 kts) = 25 gal/NM

Range:

- SS$\leq$2 = 200 NM at 40 kts fully Loaded
- 300 NM at 35 kts Empty
- SS$\geq$3 = 300 NM at 25 kts fully loaded

Endurance (E): 5,000 gal/1,000 gal/hr = 5 hrs at 40 kts fully loaded
300 NM/35 kts = 8.5 hrs empty
200 NM/25 kts = 8 hrs (assuming HLCAC can has range of 200 NM fully loaded at 25 kts)

B.2 Air Connectors

Parameters are derived for the following Connectors:

- MV-22
- CH-53X
- UH-1Y
- Advanced Air Transport (ATT)
- SkyCat ™ 1000 (SkyCat)

Standardized payloads are used to determine capacities for the connectors. For each of the capacities a weight fraction, area fraction, and volume fraction is calculated to give a measure to the packaging efficiency. These fractions are the ratio of the actual load considering packaging to the maximum capability of the platform:

Fraction = (actual/maximum)

To account for the variability in loads that comes from the friction of war, the lift capacities used to model each connector were calculated by applying this maximum to a unit normal distribution with a mean of 0.85 and a standard deviation of 0.05.

To account for the variability in pilots' ability to fly a precise airspeed, the speed values for each connector is modeled using a normal distribution with 5 kts of standard deviation.

For all distributions, the Excel™ format is used: NORM(*mean*, *standard deviation*).

Palletized Cargo

For the purpose of this analysis, all cargo is considered palletized. The "standard" pallet size was borrowed from industry and from the JMIC program. The standard pallet is considered to be 48 inches x 40 inches x 39 inches (length, width, height) or 4.00 ft x 3.33 ft x 3.25 ft. This pallet has a footprint of 13.3 sq ft and a volume of 43.3 cu ft. All of the following calculations were based on this standard pallet size.

Class I (food). Food capacity is based on a standard pallet of MRE. MREs are packaged in cases. Each case of 12 MREs weighs 22 lbs. Each pallet can carry 48 cases.[368]

(48 cases/pallet)*(22 lbs/case) = **1,098 lbs/pallet**

(48 cases/pallet)*(12 MRE/case) = **576 MREs/pallet**

Class I (water). This capacity estimate assumes that water is transported as commercial bottled water; this represents the least efficient (worst case) because of the inefficient packaging. Representative bottled water numbers were obtained from the Web.[369] From that data, the 20 oz. bottles are used because they gave the most water per case. These 20 oz. bottles come 24 per case; 72 cases per pallet. Each case weighs 33 lbs per case.

(33 lbs/case)*(72 cases/pallet) = **2,376 lbs/pallet**

(20 oz/bottle)*(1gal/128oz)*(24 bottles/case)*(72 cases/pallet) = **270 gal/pallet**

[368] Defense Logistics Agency, "Meals Ready to Eat MRE Transportation Data," available on the World Wide Web at http://www.dscp.dla.mil/subs/rations/meals/mres.htm [cited on 25 September 2004].
[369] Premier Label Water Company Website, available on the World Wide Web @ www.plwc.net/faq.htm, [cited 27 September 2004].

Class III (Fuel). This capacity is based on an externally carried, 500-gal fuel bladder filled with JP-5 fuel.

(500 gal/bladder)*(6.8 lb/gal JP-5) = **3,400 lbs/bladder of JP-5**

Class V Artillery. Based on the MAGTF Planner's Reference Manual[370] estimates of artillery rounds required, the Dual Purpose Improved Conventional Munitions (DPICM) round and the M203A Red Bag charge (RBC) were considered representative. These rounds are assumed to be loaded on a standard military ammunition skids.[371] Each skid of DPICM has 8 shells and weighs 798 lbs. Each skid of M203A has 24 charges and weighs 1,370 lbs. Because they are both required to fire the 155mm howitzer, it is assumed those 3 skids of shells and 1 skid of charges are shipped together. This package is considered a "pallet" of 155mm ammunition.

3*(798 lbs/DPICM skid) + (1,370 lbs/charge skid) = **3,764 lbs/pallet**

Small Arms. To account for the increased density of small arms ammunition, Class V capacity is also calculated for the standard 7.62 mm round.[372] 200 rounds come in a standard NATO steel ammunition box[373]. Each loaded ammunition box weighs 16.8 lbs and is 11 inches long by 7 inches high by 4 inches wide. 200 ammunition boxes fit on a pallet.

(16.8 lb/box)*(200 boxes/RBC) = **3,360 lbs/RBC**

Average Ammunition. These two values were averaged to arrive at a representative average pallet was used for modeling purposes:

Average = (Artillery + Small Arms)/2 = (3,764 + 3,360)/2 = **3,562 lbs/pallet of ammunition**

B.2.1 MV-22 Parameter Analysis

This analysis assumes that the MV-22 is a basic airframe with 2 AE1107C Rolls-Royce Allison 6,150 shaft horse-power engines, the higher-rated transmissions, and the 2-point external lift system.[374] Except where noted, the MV-22 NATOPS manual was used to calculate the following parameters.

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[370] U.S. Marine Corps, "MAGTF Planner's Reference Manual" MSTP Pamphlet 5-0.3, April 2001, pp. 75-80.
[371] Aviation Ordnancemen Website, "Ammo Skids" available on the World Wide Web @ http://www.ordnance.org/pallets.htm [cited 20 September 2004].
[372] Ibid.
[373] Flectarn Company, "Standard NATO Steel Ammo Box" available on the World Wide Web @ http://www.flecktarn.co.uk/spoab1ux.html [cited 08 December 2004].
[374] NAVAIRSYSCOM, MV-22B NATOPS Flight Manual, Preliminary, Change 3, A1-V22AB-NFM-000, June 2000. p. I-4-10.

Survivability (P_s): For the full factorial simulation runs, $P_s = 1.0$ (no combat loss). This allows the effects of the external factors to show through. See Chapter 9 for the derivation of the $P_s = 0.99$ for assault.

Reliability (MTBF): For the scenario simulation the following assumptions[375] are used:

$A_\infty = 0.8$ MTTR = 12 hrs MLOG = 1.3 hrs

and inserting these values into

$$MTBF = \frac{A_\infty \times (MTTR + MLOG)}{(1 - A_\infty)}$$

yields an MTBF $\approx$ 52 hrs. See Chapter 6 for the full derivation of MV-22 reliability.

Air Spots (I_A): Not applicable for an air assault connector.

Surface Spots (I_S): Not applicable for an air assault connector.

Cargo Area: Based on the MV-22 cargo floor dimensions.[376]

area = (16.84 ft long)*(5.7 ft wide) = **96 sq ft**

Cargo Volume: Based on the MV-22 cargo bay height.[377]

volume = (96 sq ft)*(5.4 ft high) = **518 cu ft**

Internal Weight Capacity

Aircraft balance limits are not considered. The MV-22 maximum VTOL takeoff weight (Sea Level, Standard Day) is 52,600 lbs.[378] It has an empty weight of 33,140 lbs and own-fuel weight of 9,850 lbs. The maximum internal cargo weight capacity is the difference:

Maximum cargo weight = Takeoff weight – (empty weight + full fuel weight)

= 52,600 lbs – (33,140 lbs + 9,850 lbs) = **9,610 lbs**

375 A "reasonable estimate" based on the expert opinion of three field-grade Naval Aviators and two Aviation Limited Duty Officers.
376 MV-22 NATOPS, p. I-1-11.
377 Ibid.
378 MV-22 NATOPS, p. I-4-8.

However, assuming fuel is light-loaded 400 lbs (60 gals) less than maximum capacity moves the maximum lift capacity to 10,000 lbs. This makes the internal lift limits the same as the NATOPS external lift limit of 10,000 lbs. Additionally, the cargo floor has a load limit of 300 lbs/sq ft.

Food. The MV-22 is area-limited to five pallets in the cargo bay.

(5 pallets/MV-22)*(1,098 lbs/pallet) = **5,490 lbs/MV-22**

(5 pallets/MV-22)*(576 MREs/pallet) = **2,880 MREs/MV-22**

The cargo floor load is less than the 300 lbs/sq ft limit:

(5,490 lb)/(66.6 sq ft) = 82 sq ft

Weight fraction = (5,490 lbs)/(10,510 lbs) = 0.52 = **52%**

Area fraction = (5*13.3 sq ft)/(96 sq ft) = 0.69 = **69%**

Volume fraction = (5*43 cu ft)/(518 cu ft) = 0.42 = **42%**

Fuel. The MV-22 only carries fuel externally. See External Capacity for estimated performance.

Water. The MV-22 is weight-limited to four pallets of bottled water.

(4 pallets/MV-22)*(2,376 lbs/pallet) = **9,504 lbs/MV-22**

(4 pallets/MV-22)*(270 gal/pallet) = **1,080 gal/MV-22**

The cargo floor load is less than the 300 lbs/sq ft limit:

(9,504 lbs)/(53.3 sq ft) = 178 lbs/sq ft

Weight fraction = (9,504 lbs)/(10,000 lbs) = 0.95 = **95%**

Area fraction = (4*13.3 sq ft)/(96 sq ft) = 0.55 = **55%**

Volume fraction = (4*43.3 cu ft)/(518 cu ft) = 0.33 = **33%**

Ammunition. For safety reasons, the MV-22 carries ammunition externally. See External Capacity for estimated performance.

Troops. Each MV-22 carries a maximum of 24 combat-loaded troops[379] and does not carry (internal or external) cargo with them for loading/unloading considerations.

(24 troops/MV-22)*(240 lbs/troop) = **5,760 lbs/MV-22**

Weight fraction = 5,460 lbs/10,000 lbs = 0.58 = **58%**

Litters. Each MV-22 carries **12 litters**[380] and associated medical crew.

External Lift Capacity

Area or volume limitations were not considered since cargo is carried in a sling; only weight fraction is calculated. The MV-22 has a maximum external lift capacity (single or dual-hook) of 10,000 lbs.[381] However, this lift capacity is a function of mission radius (R). Based on a mission profile flying at 110 kts with an external load to the objective and flying at 230 kts with no load back gives the following generalized payload-radius profile:

10,000 lbs for $0 \leq R \leq 145$ NM

5,000 lbs for $145 < R \leq 165$ NM

0 lbs for $R > 165$ NM

This generalized profile is applied to the capacities for each commodity.

Food. The MV-22 is weight-limited to 9 pallets of food:

(9 pallets/MV-22)*(1,098 lbs/pallet) = **9,882 lbs/MV-22**
(9 pallets/MV-22)*(576 MRE/pallet) = **5,184 MREs.**

Weight fraction = 9,882 lbs/10,000 lbs = **99%**

The food capacity is modeled by the following parameters:

NORM (8,400, 490) lbs for $0 \leq R \leq 145$ NM

NORM (3,700, 220) lbs for $145 < R \leq 165$ NM

0 lbs for $R > 165$ NM

Water. The MV-22 is weight-limited to 4 pallets.

[379] MV-22 Website, http://www.globalsecurity.org/military/systems/aircraft/v-22.htm.
[380] Ibid.
[381] MV-22 NATOPS, p. I-4-6.

(4 pallets/MV-22)*(2,376 lbs/pallet) = **9,504 lbs/MV-22**

(270 gal/pallet)*(4 pallets/MV-22) = **1,080 gal/MV-22**
Weight fraction = (9,504 lbs)/(10,000 lbs) = **95%**

The water capacity is modeled by the following parameters:

NORM (920, 55) gal for $0 \leq R \leq 145$ NM

NORM (460, 30) gal for $145 < R \leq 165$ NM

0 gal for $R > 165$ NM

Fuel. Assuming that the MV-22 carries only one 500-gallon fuel bladder per hook, with 2 hooks it can carry 2 fuel bladders.

(500 gal/bladder)*(6.8 lbs/gal JP-5) = **3,400 lbs/bladder**

(2 bladders/MV-22)*(3,400 lbs/bladder) = **6,800 lbs/MV-22**

(2 bladders/MV-22)* (500 gal/bladder) = **1,000 gal/MV-22**

Weight Fraction = 6,800 lbs/10,000 lbs = **68%**

No distribution is used since there is virtually no variability in bladder loading.

Ammunition. The MV-22 is weight-limited to carrying only 2 pallets, which equates to approximately 48 155mm rounds or 80,000 7.62mm rounds.

(2 pallets/MV-22)*(3,562 lbs/pallet) = **7,528 lbs/MV-22**
Weight Fraction = 7,528 lbs/10,000 lbs = **75%**

The ammunition capacity is modeled by the following parameters:

NORM (6,100, 360) lbs for $0 \leq R \leq 145$ NM

NORM (3,030, 180) lbs for $145 < R \leq 165$ NM

0 lbs for $R > 165$ NM

Speed. Two MV-22 speed values are assigned; one for carrying external loads, and one for internal loads.

External Loads. The MV-22 carries vehicles at 110 kts with 60-degree nacelle angle. It carries pallet loads at 120-150 kts with 30-degree nacelle angle. A normal distribution of (130, 5) in kts is used to model both loads and pilot airspeed variability.

Internal Loads. For modeling purposes, only troops are carried internally. For maneuver warfare, speed is important, so it is assumed that when carrying internal loads only, the MV-22 is traveling in airplane mode at its maximum sustained level-flight speed. At 50,000 lbs gross weight, the maximum level flight speed is 230-240 kts. To represent pilot variability, NORM (230, 5) in kts is used to model internal load transit speed.

Start Fuel (F_o): From the NATOPS fuel system descriptions[382], the maximum fuel capacity is calculated:

2*(88.2 gal/feed tank + 478 gal/fwd sponson) = 2*(566.2 gal) = 1,132.4 gal

Plus a single 316-gal alternate sponson for a total of 1,448.4 gal ≈ **1,450 gal**

(1,450 gal)*(6.8 lb/gal) = **9,860 lbs**

Fuel Usage Rate (FF): Usage rates are calculated for external and internal loads at Sea Level on a standard day for a 50,000-lb aircraft.

Fuel burn with external loads is calculated for 110 kts, nacelle angle of 60 degrees, with a drag count of 80. Figure 25-6 "Specific Range with External Load," p. XI-25-10 in the MV-22 NATOPS Manual indicates a specific range of 0.031 NM/lb or specific fuel consumption of 32.3 lbs/NM. Converting to a time rate of consumption:

(0.031 NM/lb)*(6.8 lb/gal) = 0.21 NM/gal which is 4.7 gal/NM.

At 110 NM/hr, fuel burn is approximately 520 gal/hr.

Fuel burn with internal loads is calculated for 230 kts, airplane mode, with a base aircraft drag count. Figure 25-4 "Maximum Range Performance, Airplane Mode," p. XI-25-9 in the MV-22 NATOPS Manual indicates a fuel usage rate of 0.07 NM/lb or a specific fuel consumption of 14.3 lb/NM. Converting to time rate of consumption:

(0.07 NM/lb)*(6.8 lb/gal) = 0.48 NM/gal, which is 2.1 gal/NM.

At 230 NM/hr, fuel burn is approximately 480 gal/hr.

Endurance. Calculated from the fuel flows and speeds used above and assumes no air refueling. 20% of the fuel capacity is held in reserve.

Endurance = (MAX FUEL)*(0.8)/(BURN RATE)

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[382] MV-22 NATOPS, p. I-2-56.

External load: (1450 gal)*(0.8)/(520 gal/hr) = **2.2 hrs at 110 kts**

Internal load: (1450 gal)*(0.8)/(480 gal/hr) = **2.4 hrs at 23 kts**

Un-refueled Ferry Range. For an average aircraft weight of 45,000 lb flying at 20,000 ft on a standard day, Figure 25-4 "Maximum Range Performance, Airplane Mode," p. XI-25-9 in the MV-22 NATOPS Manual indicates a specific range = 0.1 NM/lb. Assuming no auxiliary tanks, the total fuel is 9,850 lbs. Subtracting 20% for fuel reserve leaves:

un-refueled ferry range = (0.8)*(9,850 lb)*(0.1 NM/lb) ≈ **790 NM**

B.2.2 CH-53X Parameter Analysis

This analysis assumes that the CH-53X is a CH-53E Super Stallion basic airframe with a new 6,150 shaft horse-power engines (like the Rolls-Royce AE-1170C), the higher-rated transmissions, and the associated airframe modifications, including the improved 3-point lift system.[383] From this assumption, the CH-53X fuel capacity and payload bay dimensions are estimated by the CH-53E. It is assumed that the CH-53X carries 15 tons a combat radius of 100 NM flying at 3,000 ft in 33^{o}C air.[384]

Survivability (Ps): For the full factorial model runs, Ps = 1.0 (no combat loss). This allows the effects of the external factors to show through. Ps = 0.99 for the scenario simulation; see Chapter 9 for the derivation.

Reliability (MTBF): For the scenario simulation the following values are used:

MTBF = 40 $A_\infty = 0.7$ MTTR = 16 hrs MLOG = 1.3 hrs.

Inserting these values into

$$MTBF = \frac{A_\infty \times (MTTR + MLOG)}{(1 - A_\infty)}$$

yields MTBF ≈ 40 hrs.

Air Spots (I_A): Not applicable for an air assault connector.

Surface Spots (I_S): Not applicable for an air assault connector.

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[383] Helms, Douglas W., "A Bigger, Better Giant," from Rotor & Wing (http://defensedaily.com) (cited 26 September 2004).
[384] Ibid.

Cargo Area: Based on the CH-53E cargo area dimensions.[385]

area = (30 ft long)*(7.5 ft wide) = 225 sq ft.

Cargo Volume: Based on the CH-53E cargo bay height.[386]

volume = (225 sq ft area)*(6.5 ft high) = 1,460 cu ft.

Internal and External Weight Capacity

Aircraft balance limits are not considered. The CH-53X maximum takeoff weight is assumed to be approximately 80,000 lbs[387] (Sea Level, Standard Day). Assuming that the CH-53X will be slightly heavier than the CH-53E,[388] an aircraft empty weight of 35,000 lbs gives the CH-53X a maximum takeoff load of 45,000 lbs (20 tons). Up to 15,000 lbs of this 45,000 is own-ship fuel. Fully fueled, the maximum takeoff payload would be 30,000 lbs. Assuming similar capability as the CH-53E, the CH-53X is assumed to be able to lift another CH-53X[389] (17.5 tons) a distance of 20 NM. For simplicity, it is assumed that the maximum payload is 30,000 lbs, internal or external, out to a mission radius of 200 NM.

Pallet Loads. Internally, the CH-53X cargo bay floor is area limited to 14 pallets; stacked two-high gives a maximum 28 pallets by volume.

The footprint of these 14 pallets is (14 pallets)*(13.3 sq ft/pallet) = **186.2 sq ft**
Area Fraction = (186.2 sq ft)/(225 sq ft) = **83%.**

Volume Fraction = (28 pallets)*(43.3 cu ft)/(1,460 cu ft)

= (1,212 cu ft)/(1,460 cu ft) = **83%**

Again, for simplicity of analysis, it is assumed that the maximum external payload is also 28 pallets. This number of pallets requires additional packaging. It is assumed that four pallet loads can be bundled together into a "quadcon," which can be lifted as a single item.

Food. The CH-53X is weight limited, able to carry only 27 pallets.

(27 pallets)*(1,098 lbs/pallet) = **29,646 lbs/CH-53X**

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[385] Sikorsky Aircraft Company, "Sikorsky CH-53E/S-80E Super Stallion" characteristics sheet http://www.sikorsky.com/file/popup/1,,185,00.pdf (cited 23 September 2004).
[386] Ibid.
[387] Jane's All the World's Aircraft, "CH-53E," electronic resource accessed thru the Dudley Knox Library, NPS (Cited 26 September 2004).
[388] Sikorsky, CH-53E/S-80E Super Stallion fact sheet.
[389] Federation of American Scientists, "CH-35E Super Stallion" available on the World Wide Web @ http://www.fas.org/man/dod-101/sys/ac/h-53.htm (cited 26 September 2004).

(27 pallets)*(576 MREs/pallet) = **15,552 MREs/CH-53X**

Weight fraction = (29,646 lbs)/(30,000 lbs) = **99%**

Volume fraction = ((27 pallets)*(43.3 cu ft/pallet))/(1,460 cu ft)

= (1,169.1 cu ft)/(1,460cu ft) = **80%**

Area Fraction, as mentioned above, is **83%**

Water. The CH-53X is weight-limited to 12 pallets of bottled water.

(12 pallets)*(2,376 lbs/pallet) = **28,512 lbs/CH-53X**

(12 pallets/CH-53X)*(270 gal/pallet) = **3,240 gals/CH-53X**

Weight fraction = (28,512 lbs)/(30,000 lbs) = **95%**

Volume fraction = ((12 pallets)*(43.3 cu ft/pallet))/(1,460 cu ft)

= (519.6 cu ft)/(1,460 cu ft) = **36%**

Area Fraction = (12 pallets)*(13.3 sq ft)/(225 sq ft)

= (159.6 sq ft)/(225 sq ft) = **71%**

Fuel. The CH-53X only carries fuel externally. Based on the CH-53E externally carrying three 500-gallon fuel bladders,[390] it is assumed that that the CH-53X will be able to carry four bladders with its improved 3-point lift system.[391]

(4 bladders/CH-53X)*(3,400 lbs/bladder) = **13,600 lbs/CH-53X**

(4 bladders/CH-53X)*(500 gal/bladder) = **2,000 gal/CH-53X**

Weight fraction = (13,600 lbs)/(30,000 lbs) = **45%**

Area and volume fractions do not apply.

Ammunition. The CH-53X is weight-limited to carrying 8 pallets of ammunition. These 8 are assumed to be packaged in two, 4-pallet quadcons. These 8 pallets equate approximately to 190 artillery rounds or 320,000 7.62mm rounds.

[390] USMC, 15th MEU Official Photo 2001620225452 shows a CH-53E carrying three fuel bladders. Available online @ www.15meu.usmc.mil/marinelink/image1.nsf/lookup/2001620225452 (cited 27 September 2004).

[391] Helms, "A Bigger, Better Giant."

(2 quadcon/CH-53X)* (4 pallets/quadcon)*(3,562 lbs/pallet) = **28,496 lbs/ CH-53X**

Weight fraction = (28,496 lbs)/(30,000 lbs) = **95%**

Troops. Some Web resources list the troop capacity for the CH-53E at 55 personnel; however the USMC MAGTF Planning Guide uses 24.[392]

Weight = (24 troops)*(240 lbs/troop) = **5,760 lbs**

Weight fraction = (5,760 lbs)/(30,000 lbs) = **19%**

Litters. When dedicated to Medical Evacuation (MEDEVAC), each CH-53X carries 24 litters[393] and associated medical crew.

Speed. Speed characteristics are assumed to be similar to the CH-53E. External loads are carried at 110 kts. The return trip, with no or an internal load, is flown at 150 kts.[394] The trip to the objective is modeled as NORM(110; 5) and the trip back to the ship is modeled as NORM (135; 5).

Start Fuel. Assumed to be the same as CH-53E, 15,000 lbs (2,270 gal/JP5)[395]at maximum capacity.

Fuel Usage Rate. The fuel usage rate is derived by analogy with the MV-22 because of similar engine characteristics. CH-53E has three 4,250-shaft horsepower (shp) engines. According to the literature, the CH-53X will need three 6,100-shp engines to meet lift requirements.[396] This same article suggests that perhaps the MV-22 power plant will be used. Fuel flow for the CH-53X was estimated by calculating the per-engine fuel flow of MV-22 and multiplying by 3 for the CH-53Xs three engines. The estimate is based on the MV-22 external load and internal load estimates performed above.

For an externally loaded MV-22, the specific range is 0.031 NM/lb or 32.3 lb/NM. Multiplying by the associated speed of 110 NM/hr approximates fuel consumption:

(32.3 lb/NM)*(110 NM/hr) ≈ 3,550 lb/hr

Assuming both engines are performing similarly, the burn of each engine is approximately half this total, or 1,780 lb/hr. It is generally known that a conventional rotor system is more efficient than a tilt rotor system. Assuming 10% increase in

[392] USMC, MAGTF Planner's Reference Guide, p. 24.
[393] FAS, CH-53 Website http://fas.org/man/dod-101/sys/ac/h-53.htm.
[394] Sikorsky CH-53 Fact Sheet.
[395] FAS, CH-53 Website http://fas.org/man/dod-101/sys/ac/h-53.htm.
[396] Helms, "A Bigger Better Giant."

efficiency, each CH-53X engine would burn approximately 1,600 lb/hr. For all three CH-53X engines, this would equate to a combined fuel flow of approximately 4,800 lb/hr.

Again, using the MV-22 as an analogies system an internally loaded MV-22, the specific range is 0.07 NM/lb or 14.3 lb/NM. Multiplying by the associated speed of 230 NM/hr approximates fuel consumption:

$$(14.3 \text{ lb/NM})*(230 \text{ NM/hr}) \approx 3{,}300 \text{ lb/hr}$$

Again, assuming both engines are performing similarly, the burn of each engine is approximately half this total, or 1,650 lbs/hr. Assuming 10% increase in efficiency, each CH-53X engine would burn approximately 1,500 lb/hr. For all three CH-53X engines, this would equate to a combined fuel flow of approximately 4,500 lbs/hr.

Endurance. Calculated from the fuel flows and speeds used above. This endurance estimate is only for the mission profile mentioned above, not the maximum endurance of the basic airframe. This estimate assumes neither air refueling nor a Forward Advanced Refueling Base (FARP). Assuming a 20% fuel reserve leaves only 80% maximum fuel capacity.

$$\text{Endurance} = ((\text{MAX FUEL CAPACITY})*(0.8))/(\text{BURN RATE}))$$

$$\text{loaded} = ((15{,}000 \text{ lbs}*0.8)/(4{,}800 \text{ lbs/hr})) = 2.5 \text{ hrs}$$

$$\text{empty} = ((15{,}000 \text{ lbs}*0.8)/(4{,}500 \text{ lbs/hr})) = 2.7 \text{ hrs}$$

Un-refueled Ferry Range. Also derived by analogy with the MV-22. From the MV-22 NATOPS manual, the specific range of a fully-fueled MV-22 carrying no cargo, 220 kts, 5,000 ft, standard day, is approximately 0.085 NM/lb. Using the same 20% fuel reserve as above:

$$\text{Ferry Range} \approx (\text{specific range})*(\text{available fuel})$$

$$= (0.085 \text{ NM/lb})*((15{,}000 \text{ lbs})*(0.8)) = 1{,}020 \text{ NM}$$

This estimate is very comparable with the CH-53E un-refueled ferry range of 990 NM.[397]

B.2.3 UH-1Y Parameter Analysis

UH-1Y has flown. Preliminary performance data shows it to be significantly more capable than the UH-1N.[398] Although multi-mission capable, it is only modeled as a MEDEVAC platform.

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[397] FAS CH-53 Website, http://fas.org/man/dod-101/sys/ac/h-53.htm.

Survivability (Ps): For full factorial, 1.0 (no combat loss). This allows the effects of the external factors to show through. See Chapter 9, Scenario for the derivation of the Ps = 0.99 for assault.

Reliability (MTBF): For the scenario simulation it is modeled as the same as a CH-53X.

Air Spots (I_A): Not applicable for an air assault connector.

Surface Spots (I_S): Not applicable for an air assault connector.

Cargo Area: Based on estimated cargo area dimensions:

area = (8 ft long)*(8 ft wide) = 64 sq ft.

Cargo Volume: Based on estimated cargo bay height:

volume = (64 sq ft area)*(5 ft high) = 320 cu ft.

Internal and External Weight Capacity

12,000 lb empty weight, 2,600 lb fuel, and 3,200 lb payload.[399] Aircraft balance limits are not considered.

Pallet loads. The UH-1Y is not designed to carry palletized cargo. No cargo loads are calculated.

Troops. Four, besides the pilots.[400]

Litters. Two wounded.[401]

Speed. The UH-1Y top speed is listed a 158 kts.[402] MAGTF Planners Reference Guide shows the UH-1N flying at 110 kts.[403] Speed modeled at NORM (100; 5) in kts.

Start Fuel. 380 gal (2,580 lbs JP-5), 457 gal (3,110 lbs JP-5) w/auxiliary tanks.[404]

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398 Bell Helicopter, "UH-1Y Pocket Guide," (September 2004 (cited 04 December 2004)) available on the World Wide Web @ http://www.bellhelicopter.textron.com/en/aircraft/military/pdf/UH1Y_PG_04_web.pdf.
399 Bell Helicopter, "UH-1Y Pocket Guide."
400 MAGTF Planner's Reference, p. 24.
401 "UH-1Y Iroquios, Huey," (September 2004 (cited 04 December 2004) available on the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/uh-1.htm.
402 Bell Helicopter, "UH-1Y Pocket Guide."
403 MAGTF Planner's Reference, p. 24.
404 Bell Helicopter, "UH-1Y Pocket Guide."

Fuel Usage Rate (FF): Specific range is estimated from the UH-1Y preliminary performance results for a troop insertion at 3,000 ft at 33 deg C:

Mission range = 2*mission radius = 2*130 NM = 260 NM

Useable fuel = 80% of maximum capacity = 0.8 * 2,680 lbs= 2,140 lbs

Specific range = range/fuel used = 260 NM/2,140 lbs = 0.12 NM/lb or 8.2 lb/NM

Specific fuel consumption is estimated by multiplying specific range by speed:

(8.2 lb/NM)*(135 NM/hr) ≈ **1,100 lbs/hr**

Endurance. 3 hrs.[405]

Un-refueled Ferry Range. 200 NM as a conservative estimate based on Bell preliminary performance data and subsequent tests.[406]

B.2.4 ATT Parameter Analysis

This analysis assumes that the ATT is a four-engine turbo prop/tilt wing aircraft. The tilt wings produce an advertised super short takeoff and landing capability. This C-130-sized air transport operates form the MPF(F) Aviation ship. Much of the ATT's performance is based on the basic C-130 airframe. However, the concept is for a payload of twice the C-130J.[407]

Survivability (Ps): The same Ps of 0.99 is used for ATT as for the other air connectors. See Chapter 9 for the derivation.

Reliability (MTBF): Because the ATT is modeled as a replacement for the CH-53X, its reliability is assumed to be the same as the CH-53X, ≈ 40 hrs.

Air Spots (I_A): Not applicable for an air assault connector.

Surface Spots (I_S): Not applicable for an air assault connector.

Cargo Area: Based on the C-130J cargo floor dimensions[408] lengthened to accommodate 3 HUMVEEs:

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[405] Ibid.
[406] Global Security, "UH-1N Specifications" (28 November 2001) available @ http://www.globalsecurity.org/military/systems/aircraft/uh-1-specs.htm (cited 26 September 2004).
[407] Global Security, "Advanced Theater Transport (ATT)" (01 December 2002 [cited 04 December 2004]) available on the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/att.htm.
[408] Global Security, "C-130J Specifications" available on the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/c-130j-specs.htm [cited on 04 October 2004].

area = (48 ft long)*(10.25 ft wide) ≈ **490 sq ft**

Cargo Volume: Based on the C-130J cargo bay height.[409]

volume = (410 sq ft)*(9 ft high) = **4,428 cu ft**

Internal Weight Capacity

Aircraft balance limits are not considered. By analogy with the C-130J, the ATT empty aircraft weight is assumed to be 75,600 lbs. The maximum cargo weight capacity is estimated to be 80,000 lbs.[410] The ATT's maximum payload for "Super Short Takeoff and Landing." is 60,000 lbs (Sea Level, Standard Day). Because shipboard operations and combat landing strip operations are the concept of operations, 60,000 lbs is considered the useable payload. Although the capacities for all commodities are shown below, the ATT is only used to transport three HUMVEE vehicles in the Alternative Architecture III concept of operations. To use the minimum amount of flight deck and of expeditionary runway, the ATT is modeled during the sustainment phase with only 14,960 lbs of own-fuel.

HUMVEEs. A representative HUMVEE is 16 ft long, 7 ft wide, 6 ft high and weighs 9,500 lbs.[411] Its footprint is 114 sq ft, and volume is 685 cu ft. The ATT is length-limited to 3 HUMVEEs in the cargo bay.

Weight fraction = (3 *(9,500 lbs))/(60,000 lbs) = **48%**

Area fraction = ((3*114 sq ft))/(490 sq ft) = **70%**

Volume fraction = ((3)*(685 cu ft))/(4,428 sq ft) = **46%**

Pallets. Based on the dimensions of the standard pallet and the cargo bay dimensions, only 36 pallets will fit on the floor and can only be stacked two-high, for a maximum of 72 pallets.

Area fraction = (36 pallets/ATT)*(13.4 sq ft/pallet))/(490 sq ft) = **98%**

Volume fraction = (72 pallets/ATT)*(43.3 cu ft /pallet))/(44,28 cu ft) = **70%**

Food. The ATT is weight-limited to 54 pallets of MREs.

# of pallets = round down(60,000 lbs)/(1,098 lb/pallet) = **54 pallets**

(54 pallets/ATT)*(1,098 lbs/pallet) ≈ **59,300 lbs/ATT**

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[409] Ibid.
[410] Global Security ATT Website.
[411] Global Security, "HMWW Specifications," available on the World Wide Web @ http://www.globalsecurity.org/military/systems/ground/images/hmmwv-basic-dim.jpg (January 2003) [cited 09 December 2004].

(54 pallets/ATT)*(576 MREs/pallet) = **31,104 MREs/ATT**

Weight fraction = 59,300 lbs/60,000 lbs = **99%**

Area fraction, assuming whole floor is filled first, is **98%**

Volume fraction = (54*43.3 cu ft)/(4,428 cu ft) = **53%**

Water. The ATT is weight-limited to 25 pallets of bottled water.

(25 pallets/ATT)*(2,376 lbs/pallet) = **59,400 lbs/ATT**

(25 pallets/ATT)*(270 gal/pallet) = **6,750 gal/ATT**

Weight fraction = 59,400 lbs/60,000 lbs = **99%**

Area fraction = (25*13.3 sq ft)/(490 sq ft) = **68%**

Volume fraction = (25*43.3 cu ft)/(4,428 cu ft) = **24%**

Fuel. 115,000 lbs available give,[412] subtracting 23,000 lbs as a 20% reserve and 4,000 lbs as the single trip fuel, ATT can offload approximately 80,000 lbs at the objective area.

Ammunition. The ATT is weight-limited to carrying 16 pallets of ammunition.

# of pallets = round down(60,000 lbs)/(3,562 lb/pallet) = **16 pallets**

(16 pallets/ATT)*(3,562 lb/pallet) = **56,992 lbs/ATT**

This is equivalent to approximately 380 155-mm rounds or 640,000 7.62mm rounds.

Weight fraction = 56,992 lbs/60,000 lbs = **95%**

Area fraction = (16*13.3 sq ft)/(490 sq ft) = **43%**

Volume fraction = (16*43.3 cu ft)/(4,428 cu ft) = **16%**

Troops. Each ATT carries a maximum of 100 combat-loaded troops[413] and does not carry cargo with them for loading/unloading considerations.

Weight = (100 troops)*(240 lbs/troop) = **24,000 lbs**

Weight Fraction = 24,000 lbs/60,000 lbs = **40%**

[412] Global Security, available on the World Wide Web @ globalsecurity.org/military/systems/ATT.htm.
[413] Ibid.

Litters. Each ATT carries **74 litters**[414] and associated medical crew.

Speed. Except during takeoff and landing, the ATT is envisioned to fly with zero wing angle. In this configuration, it is much like a C-130J. By analogy with the C-130J, the ATT transits around its best range speed, 300-330 kts.[415] To represent pilot variability and to reflect the change in speed with payload, NORM (300, 5) in kts is used to model ATT transit speed.

Start Fuel. The ATT has a maximum internal fuel capacity of 115,000 lbs/16,911 gal.[416] As mentioned above, the start fuel is modeled at 14,960 lbs/2,200 gal to permit the super-short takeoff and land at sea and at the objective.

Fuel Usage Rate (FF): ATT fuel flow is estimated by analogy with the C-130H. The C-130H flies 2,049 NM[417] on 60,000 lbs of fuel at maximum payload. This equates to a specific range of approximately 0.034 NM/lb or a specific fuel consumption of 29.3 lb/NM (4.3 gal/NM). Assuming that the ATT engines will achieve a 25% increase in efficiency over the C-130H, the modeled fuel usage rate is 3.3 gal/NM. At 300 kts, this is approximately 990 gal/hr.

Endurance. Calculated from the fuel flows and speeds used above. This endurance estimate is only for the mission profile mentioned above, not the maximum endurance of the basic airframe. This estimate assumes neither air refueling nor a FARP. Twenty percent of the fuel capacity is held in reserve.

Endurance = (MAX FUEL AVAILABLE)*(0.8)*(BURN RATE)

At sea load: ((2,200 gal)*(0.8))/(990 gal/hr) = **1.8 hrs at 300 kts**

Un-refueled Ferry Range. Assumed to be the maximum range of the C-130H at maximum payload with 60,000 lbs fuel = **2,049 NM**

B.2.5 SkyCat ™ 1000 (SkyCat) Parameter Analysis

The SkyCat is a hybrid air vehicle in development by Advanced Technologies Group, UK.[418] It could be used as either an inter-theater or intra-theater transport and can be configured to carry passengers and/or heavy cargo (only cargo will be evaluated below). This vehicle combines lighter-than-air airship technology and air-cushioned

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414 Ibid.
415 Ibid.
416 Ibid.
417 Global Security, "C-130H Specifications," available on the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/c-130-specs.htm, updated 08 November 2001 [cited 10 November 2004].
418 Advanced Technologies Group, "SkyCat Hybid Air Vehicle, United Kingdom," (22 October 2004 (cited 04 December 2004), available at the World Wide Web @ http://www.aerospace-technology.com/projects/skycat.

hovercraft technology which makes it capable of landing on flat land, grass, swamp, water (including the open ocean)[419] or snow.[420] Utilizing reverse thrust on the hovercraft engines (suck-down mode) will allow it to remain stationary.[421] This feature will enable it to operate without a ground crew or ground infrastructure. It will be able to unload ashore and is assumed to be able to unload at the MPF(F) after a water landing. Although not specifically stated, the smaller SkyCat versions have both vertical and short take off and landing capability, it is assumed that this model would also have that capability. Since, payload and range are decreased for vertical operations (approximately 30% less payload and approximately 50% less range) only the short take off and landing method is addressed below (maximum payload).

For Architecture III, SkyCat is modeled as carrying MV-22 and the other tactical helicopters from CONUS to the FLS. For this reason, vehicle load capacity is estimated. Additionally, a single SkyCat deploys to the Sea Base and conducts resupply mission between the remains with the Sea Base and the FLS, carrying only palletized cargo. For these missions, payload for each commodity is estimated based on the standard air connector pallets mentioned above, recognizing that a platform this large would likely use a larger form of packaging.

Max Operating Altitude: 9,005 ft (2,745 m).[422]

Dimensions: 1,007 ft in length, 446 ft wide and 252 ft high.[423]

Survivability (Ps): The SkyCat traveled from CONUS to the FLS and between the Sea Base and the FLS; it did not proceed to the objective. The modeled Ps value of 1.0 assumes no threat in transit.

Reliability (MTBF): Similar to the MPF(F) vessels, the SkyCat MTBF was modeled as 9,999 hrs, which assumes near-perfect reliability.

Air Spots (I_A): Not applicable for an air assault connector.

Surface Spots (I_S): Not applicable for an air assault connector.

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[419] E-mail conversation with Paul Macey, Design Engineer, ATG Ltd. on 29 October 2004.
[420] Advanced Technologies Group "SkyCat Hybid Air Vehicle, United Kingdom," (22 October 2004 (cited 04 December 2004), available at the World Wide Web @ http://www.aerospace-technology.com/projects/skycat.
[421] E-mail conversation with Paul Macey, Design Engineer, ATG Ltd. on 27 October 2004.
[422] Advanced Technologies Group, "SkyCat Hybid Air Vehicle, United Kingdom," (22 October 2004 (cited 04 December 2004), available at the World Wide Web @ http://www.aerospace-technology.com/projects/skycat.
[423] Jane's All The World's Aircraft, 2004-2005, p. 509.

Cargo Area: Based on the design cargo hold floor dimensions.[424]

area = (49 ft wide)*(328 ft long) ≈ **16,000 sq ft**

The payload bay is designed to accommodate removable mezzanine decks that allow smaller items to be stacked. Up to three mezzanines may be installed to permit many levels inside the cargo pay. These mezzanines reduce the floor area of each by approximately 10% to 14,400 sq ft.

Cargo Volume: Based on the design cargo bay height.[425]

volume = (16,072 sq ft)*(26.4 ft high) = **424,300 cu ft**

Internal Weight Capacity

Aircraft balance limits are not considered. The design Maximum Payload Capacity is 1,000,000 kg or an equivalent 2,205,000 lbs.[426] Each mezzanine can carry approximately 1,058 pallets by area, 2,116 stacked two-high.

Vehicles: The SkyCat could be used to transport vehicles in the following quantities (limits for both area and weight are calculated; however, the smaller of the two numbers is highlighted and must be utilized). Although only large air vehicles are computed, all of the small helicopters could also be carried. For a mixture of vehicles the weight and area numbers can be utilized to compute specific values.

[424] E-mail conversation with Paul Macey, Design Engineer, ATG Ltd. on 27 October 2004.
[425] Ibid.
[426] Ibid.

Table B-1 shows which equipment is area limited and which is weight limited.

Vehicle	Weight (lbs)	Area (sq ft)	Number of Decks Utilized	Quantity for Area Limit	Quantity for Weight Limit
CH-53	33,226	1719.2	1*	**9**	66
MV-22	33,140	1160.5	1*	**13**	66
M1A1	133,815	387	1	41	**16**
EFV-P	72,879	360	1	44	**30**
ABV	1,350	468	3	**92**	1633
AVLB	93,194	468	1	34	**23**
M88A2	141,173	340.5	1	47	**15**
M9 ACE	37,799	215.3	1	74	**58**
HMMWV 998	8,918	109.3	2	264	**247**
LAV 25	28,685	173.3	1	92	**76**
MTVR	45,008	214.4	1	74	**48**
4K Forklift	12,004	106.2	2	272	**183**
Contact Truck	22,200	214.4	2	134	**99**
EFSS	5,300	88.6	3	489	**415**
HIMARS	47,118	214.4	1	74	**46**
LVS MK48 w MK14	114,050	322.7	1	49	**19**

Table B-1: MEB Equipment load for SkyCat.
***Note:** Limited to one deck due to height of vehicle.

Pallets. Assuming that mezzanines are installed to permit many levels of pallets, each level is 10% smaller than the value above, or 14,400 sq ft. Using this value, each mezzanine can carry approximately 1,058 pallets by area, 2,116 stacked two-high. For two mezzanines, available area is 28,800 sq ft; for three it's 43,200 sq ft.

Food. The SkyCat is weight-limited to 2,008 pallets.

(2,008 pallets)*(1,098 lb/pallet) = **2,204,784 lb**

(2,008 pallets)*(576 MREs/pallet) = **11,566,078 MREs**
Weight fraction = (2,204,784 lbs)/(2,205,000 lbs) = **99%**
Area fraction = ((1,058 pallets)*(13.3 sq ft/pallet))/(43,200 sq ft) = **33%**

volume fraction = (2,008 pallets)*(43.3 cu ft))/(424,300 cu ft) = **23%**

Water. The SkyCat is weight-limited to 927 pallets of water.

927 pallets)*(2,376 lbs/pallet) = **2,202,552 lbs**

(927 pallets * 270 gal/pallet) = **250,290 gallons**

Weight fraction = (2,202,552 lbs)/(2,205,000 lbs) = **99%**

Area Fraction = (927 pallets)*(13.3 sq ft/pallet))/(43,200 sq ft) = **29%**

Volume fraction = (2,008 pallets)*(43.3 cu ft))/(424,300 cu ft) = **23%**

Fuel. SkyCat is not considered as an alternative to refueling at sea. However, if the SkyCat were to be used to bring fuel direct to the objective, the unit for moving fuel would be the standard tanker truck, as with the LCAC. This estimate is based on the capacity of the XM1091 Fuel/Water Tanker Truck. This truck has a liquid capacity of 1,500 gallons. External dimensions of the XM1091[427] are 26.4 ft. long x 8.8 ft. wide for a total footprint of 232.2 sq ft. and a total weight of 24,194 lbs.

The SkyCat, is weight-limited to carrying 91 trucks. They can only be carried with a single mezzanine loaded.

(91 trucks)*(24,194 lbs/truck) = **2,201,654 lbs**

(91 trucks)*(1,500 gal/truck) = **136,500 gals**

(91 trucks)*(232.2 sq ft/truck) = **21,130 sq ft**

Weight Fraction = (2,201,654 lbs)/(2,205,000 lbs) = **99.8%**

Area Fraction = (21,130.2 sq ft)/(28,800 sq ft) = **73.0%**

Ammunition. SkyCat is weight-limited to approximately 619 pallets of ammunition. This is approximately 14,856 155mm rounds or 24,460,000 7.62mm rounds.

(619 pallets)*(3,562 lbs/pallet) = 2,204,878 lbs

weight fraction = (2,204,878 lbs)/(2,205,000 lbs) = 99.9%
area fraction = ((619 pallets)*(13.3 sq ft/pallet))/(16,000 sq ft) = 5%

volume fraction = ((619 pallets)*(43.3 cu ft/pallet))/(424,300 cu ft) = 6%

Commodity capacities are modeled with the following distributions to account for load variability.

Food: Norm(1,873,780; 110,222) lbs

Water: Norm(212,746; 12,515) gal

Ammunition: Norm(1,872,593; 93,630) lbs

Speed (V): 114 miles/hr listed as cruising speed (99 kts). Speed for all loads modeled as NORM(100, 5) in kts.

[427]Global Security, "HUMWW XM1091 Specifications," available online @ http://www.globalsecurity.org/military/systems/ground/m1091.htm, (cited 27 September 2004).

Start Fuel (F_0): By analogy with the SkyShip 600 B (SkyShip).[428] The SkyCat is designed to be approximately 6 times bigger than the SkyShip. Assuming that the fuel tank scales up linearly, the estimated fuel capacity is 1,000 to 1,100 gal or 6,800 to 7,200 lbs.

Fuel Usage Rate: Airship will utilize six 11,185 kW (15,000 shp) engines (Kuznetsov NK-12M turboprops)[429] and fuel consumption is expected to be 0.38 lb/hp-hr.

Range: SkyCat range is estimated at cruising altitude of 4,000 ft. from the theoretical performance chart in Figure B-1 provided by ATG Ltd.

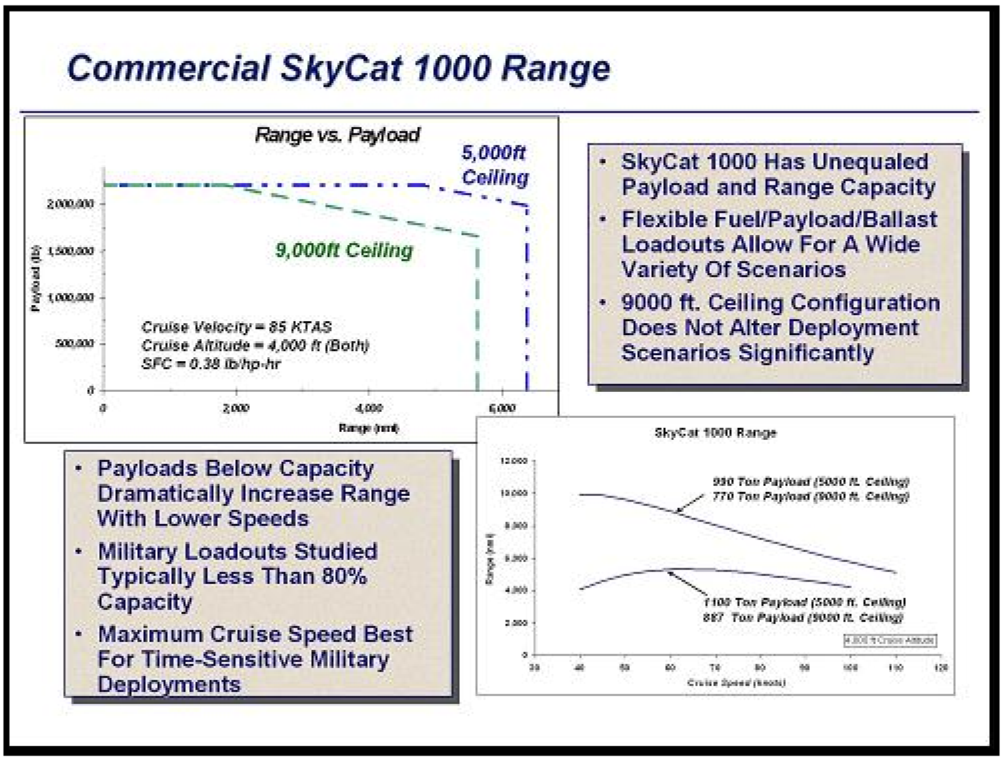

Figure B-1: SkyCat payload-range by ATG, Ltd.

Range summary:

10,000 NM @ 40 kts with 990 ton payload
6,000 NM @ 100 kts with 990 ton payload
4,000 NM @ 100 kts with 1,100 ton payload

[428] Global Skyship Industries, Inc., "SKYSHIP 600B BLIMB/AIRSHIP SPECIFICATIONS," available on the World Wide Web @ http://www.globalskyships.com/gss2.htm, (cited 04 December 2004).
[429] E-mail conversation with Paul Macey, Design Engineer, ATG Ltd. on 29 October 2004.

Endurance (E): Based on a 4,000 NM range at 100 kts with a 1,100 ton payload.

Specific range is estimated by dividing range by estimated fuel capacity.

(4,000 NM)/(7,000 lb fuel) = 0.57 NM/lb, which equates to 1.75 lb/NM

Specific fuel consumption is estimated by multiplying this value by the speed.

(1.75 lb/NM)*(100 NM/hr) = 175 lb/hr

Dividing estimated fuel capacity by estimated specific fuel consumption equates to approximately 40 hrs of endurance at 100 kts.

B.3 Transfers Parameter Analysis

Transfers are modeled as time delays associated with loading a connector with the payload it has been assigned to deliver. SEA-6 modeled two types of transfer delays. The surface connector delays are associated with the use on an Integrated Landing Platform (ILP) and the air connector delays are associated with the loading of internal and external loads.

B.3.1 ILP Parameter Analysis

The primary assumption for ILP operations is that the MPF(F) will maintain position to keep the operational ILP(s) on the leeward side. The assumption further states that the MPF(F) vessel provides enough shelter to effectively reduce the sea state by 1 state. Therefore, in sea state 4 conditions, the ILP will effectively be subjected to sea state 3 conditions on the leeward side.

Transfer delay values are calculated from a combination of both current operational values for LCAC transfer delays. In this study, they are representative of both the HLCAC and LCU(R). LCAC transfer delays as well as experimental Joint Logistics Over The Shore (JLOTS) data for skin-to-skin vehicle transfers. Current operational LCAC transfer delays for well-deck operations are listed as 62 minutes for vehicles and 120 minutes for cargo.[430] Off-load delays at the beach are estimated to be 30 minutes for vehicles and 120 minutes for cargo.[431] For the baseline delay calculations, vehicle on-load and off-load times are referenced. Very limited JLOTS data for vehicle transfer rates is available for sea states greater than two. JLOTS transfer rate data for sea states 0-2 is very scattered with observations between 1 and 50 vehicles per hr possible. However, in sea state 3 conditions, the data is very limited. The highest

[430]"Landing Craft, Air Cushion," (09 August 2004 [cited 05 October 2004]); available on the World Wide Web @ http://www.globalsecurity.org/military/systems/ship/lcac-specs.htm.
[431] Ibid.

transfer rate achievable so far in sea state 3 conditions is 1-2 vehicles per hr. No data is available for sea states greater than 3.[432]

Another assumption for ILP transfer delays is that the storage and inventory system that feeds the ILP is more advanced than a well-deck. No data was found to quantify this advantage, so a modest 20% efficiency is assumed for ILP operations.

ILP Transfer Delay Sea State 2: Assumption is that the effective sea state on the leeward side is one and that transfer rates are 20% faster than current LCAC well-deck operations due to inventory and storage efficiencies. This provides a mean value of 0.8 hrs per transfer. Additional percentiles for the transfer delay are depicted in Table B-2. These values represent the probability of delay based on vehicle loadout on LCAC missions (shorter delays for loads with only a few vehicles and longer delays for loads with more vehicles). The data is then fitted to a distribution using ReliaSoft Weibull ++ Softare version 6.0. The distribution for sea state 2 is best represented by a Weibull distribution with a Beta of 1.2035, Eta of 0.5344, and a Gamma of 0.4547.

Transfer Delay (Hours)	Percentile
0.5	5
0.7	25
0.8	50
1.5	90
2	95

Table B-2: Sea state 2 ILP transfer delay data.

ILP Transfer Delay Sea State 3: Assumption is that the effective sea state on the leeward side of the MPF(F) is two. Current well-deck operational transfer rates are used as the mean. Additional percentiles for the transfer delay are depicted in Table B-3. These values represent the probability of delay based on the vehicle loadout on LCAC missions. The data was then fitted to a distribution using ReliaSoft Weibull ++ Softare version 6.0. The distribution for sea state 3 is best represented by a Weibull distribution with a Beta of 0.8853, Eta of 0.3759, and a Gamma of 0.7870.

Transfer Delay (Hours)	Percentile
0.8	5
0.9	25
1.0	50
1.75	90
2.25	95

Table B-3: Sea State 3 ILP transfer delay data.

[432] Personal conversation with Guinevere Boyd of Naval Surface Warfare Center, Carderock Division (NSWCCD) on 20 October 2004.

ILP Transfer Delay Sea State 4: Assumption is that the effective sea state on the leeward side of the MPF(F) is three. Experimental JLOTS skin-to-skin transfer rates of 1-2 vehicles per hr are used to derive delay values. Percentiles for the transfer delay are depicted in Table B-4. These values represent the probability of delay based on the number vehicle loadout on LCAC missions. The data was then fitted to a distribution using ReliaSoft Weibull ++ Softare version 6.0 (ReliaSoft). The distribution for sea state 4 is best represented by a Weibull distribution with a Beta of 2.0286, Eta of 2.2801, and a Gamma of 0.9794.

Transfer Delay (Hours)	Percentile
1	20
1.5	40
2	50
2.5	80
3	95

Table B-4: Sea State 3 ILP transfer delay data.

B.3.2 Air Connector Loading Parameter Analysis

The primary assumption for CH-53 and MV-22 transfer-at-sea is that the transfer delay is not a function of sea state due to the large size of the proposed MPF(F) ships. The MPF(F) ships are considered stable with identical transfer delays for sea states 2, 3, and 4. The transfer delay consists of the time required to commence a maneuver from port or starboard observation to a hover over the operational deck spot, pick-up the external load, and then depart and clear the deck spot. The baseline CH-53X transfer delay value is 1 minute. It is calculated based on actual observations of current CH-53 Vertical Replenishment (VERTREP) operations from fleet experience.[433] The MV-22 transfer delay is predicted to be longer than the CH-53 due to larger downwash forces present underneath the MV-22. Due to the larger downwash forces, the MV-22 is predicted to hover at a higher altitude producing a more challenging external hook-up. The combination of the higher downwash forces and the higher hover altitude during the transfer operation are estimated to add an additional minute to the transfer delay compared to the CH-53. The MV-22 transfer delay is 2 minutes.[434]

B.4 Inventory and Storage Parameter Analysis

The primary assumption for the inventory and storage operations is that the MPF(F) will have a more advanced inventory and storage system. The assumption further states that the MPF(F) vessel have the ability to strike-up and strike-down cargo

[433] Hoivik, Thomas, Professor, Test and Evaluation, Operations Analysis Curriculum, [personal interview], Naval Postgraduate School, Monterey, CA, 2004.
[434] Ibid.

in conditions up to sea state 4. Sea states 0-2 are modeled the same with separate times for sea state 3 and 4.

Inventory and storage delay values are calculated from a combination of both current operational strike-up/strike-down transfer delays as well as published Supply logistics requirement times. Current DoD logistics are moving toward use of Radio Frequency Identification (RFID) tags and are assumed will be completely implemented by 2015. Faster computers and more advanced software coupled with near-real time visibility of logistics will enable the Sea Base to prepare cargo for the next days needs. The MPF(F) ships will operate using a 12-hrs on and a 12-hrs off concept, of which the 12 hrs off will provide time to UNREP/VERTREP and prestage cargo for the following day's mission. Additionally, the MPF(F) vessels built with selective offload will enable more efficient movement of cargo between staging areas and the cargo holds. Unfortunately, material handling equipment is not expected to be different than what is used currently.

Overall, little or no data was found to model strike-up or strike-down functions. However some data was provided by a Naval Surface Warfare Center (NSWC) study[435] that listed strike-down times onboard a LHD and a CVN. This data was obtained during pier side operations and was used to extrapolate times during sea states 0-2.

B.4.1 Strike-Up

Strike-Up Delay Sea State 0-2: Assumption is that the effective sea state will have no impact on the inventory and storage functions to include movement and packaging of cargo to staging areas. Using published supply response times[436] and that the cargo would be prestaged with only minor changes a strike-up delay of 10 minutes was used. This provides a mean value of 0.1667 hrs per strike-up. Additional percentiles for the transfer delay are depicted in Table B-5. These values represent the probability of delay based on speed of moving prestaged cargo or last minute changes. The data is then fitted to a distribution using ReliaSoft. The distribution for sea state 2 is best represented by a lognormal distribution with a mean of 0.1667 and a standard deviation of 1.

Transfer Delay (Hours)	Percentile
0.116	10
0.133	25
0.167	50
.5	75
1	90

Table B-5: Sea state 0-2 Strike-up delay data.

[435] McCammon, Tom, Naval Surface Warfare Center Carderock Division (NSWCCD), LHD and CVN Time Study, conducted by Naval Packaging, Handling, Storage and Transportation (PHST) Center, November 2002.
[436] Afloat Supply Procedures, NAVSUP Publication 485.

Strike-Up Delay Sea State 3: Assumption is that the effective sea state will have little impact on the inventory and storage functions to include movement and packaging of cargo to staging areas. Using above response times and adding a 10% increase due to sea state effects a mean value is 0.1883 hrs per strike-up. Additional percentiles for the transfer delay are depicted in Table B-6. These values represent the probability of delay based on speed of moving pre-staged cargo or last minute changes. The data is then fitted to a distribution using ReliaSoft. The distribution for sea state 3 is best represented by a lognormal distribution with a mean of 0.1883 and a standard deviation of 1.1.

Transfer Delay (Hours)	Percentile
0.133	10
0.15	25
.188	50
.55	75
1.1	90

Table B-6: Sea State 3 Strike-up delay data.

Strike-Up Delay Sea State 4: Assumption is that the effective sea state will have an impact on the inventory and storage functions to include movement and packaging of cargo to staging areas. Using above response times and adding a 50% increase due to sea state effects a mean value is 0.2 hrs per strike-up. Additional percentiles for the transfer delay are depicted in Table B-7. These values represent the probability of delay based on speed of moving pre-staged cargo or last minute changes. The data is then fitted to a distribution using ReliaSoft. The distribution for sea state 4 is best represented by a lognormal distribution with a mean of .25 and a standard deviation of 1.2.

Transfer Delay (Hours)	Percentile
.175	10
.2	25
.25	50
.75	75
1.5	90

Table B-7: Sea State 4 Strike-up delay data.

B.4.2 Strike-Down

Strike-Down Delay Sea States 0-2: Assumption is that the effective sea state will have no impact on the inventory and storage functions to include movement of cargo from staging areas to storage area. Using the NSWC study times[437] and the fact that cargo is on-loaded faster than it can be put away, a strike-down delay of 31 minutes was used. This provides a mean value of 0.52 hrs per strike-down. Additional percentiles for the

[437] McCammon, November 2002.

transfer delay are depicted in Table B-8. These values represent the probability of delay based on the speed of moving and storing cargo. The data is then fitted to a distribution using ReliaSoft. The distribution for sea state 2 is best represented by a lognormal distribution with a mean of 0.52 and a standard deviation of 0.13.

Transfer Delay (Hours)	Percentile
0.25	10
0.33	25
0.52	50
.75	75
1	90

Table B-8: Sea state 0-2 Strike-down delay data.

Strike-Down Delay Sea State 3: Assumption is that the effective sea state will have little impact on the inventory and storage functions, to include movement of cargo from staging area to storage area. Using above response times and adding a 10% increase due to sea state effects a mean value is 0.57 hrs per strike-down. Additional percentiles for the strike-down delay are depicted in Table B-9. These values represent the probability of delay based on the speed of moving and storing cargo. The data is then fitted to a distribution using ReliaSoft. The distribution for sea state 3 is best represented by a lognormal distribution with a mean of 0.57 and a standard deviation of 0.14.

Transfer Delay (Hours)	Percentile
0.3	10
0.383	25
.57	50
.816	75
1.1	90

Table B-9: Sea state 3 Strike-down delay data.

Strike-Down Delay Sea State 4: Assumption is that the effective sea state will have an impact on the inventory and storage functions to include movement of cargo from staging area to storage area. Using above response times and adding a 50% increase due to sea state effects a mean value is 0.65 hrs per strike-down. Additional percentiles for the transfer delay are depicted in Table B-10. These values represent the probability of delay based on the speed of moving and storing cargo. The data is then fitted to a distribution using ReliaSoft. The distribution for sea state 4 is best represented by a lognormal distribution with a mean of 0.65 and a standard deviation of 0.16.

Transfer Delay (Hours)	Percentile
.366	10
.5	25
.65	50
1.13	75
1.5	90

Table B-10: Sea State 4 Strike-down delay data.

Appendix C: Cost Analysis Data

C.1 Introduction

Appendix C contains the calculations used to generate the cost estimation contained in this report and includes samples of each formula used for computations. For costing purposes, this appendix contains two sections: acquisition cost data and operating and support (O & S) cost data. Calculations are demonstrated for each category in the overall Life Cycle Cost (LCC) of the cost estimation.

The calculations in this appendix highlight the steps taken to perform the cost estimate of the 2015 Baseline Architecture [Chapter 8]. Cost estimates for each platform contain the acquisition and O & S costs in order to generate the LCC for each platform. In addition to performing a cost estimate for the 2015 Baseline Architecture, a cost estimate for each alternative architecture is prepared. The methodology used in the 2015 Baseline Architecture includes the same steps taken to generate the alternative architecture cost estimates found in Chapter 15.

C.2 2015 Baseline Architecture Summary

Microsoft™ Excel is the primary tool used to record and track all cost data and is instrumental in forming the LCC for each platform. Table C-1 shows a sample Excel spreadsheet.

Platform Type	Acquisition Cost	Acq Year	BY04 Indice	Acq Cost (BY04$)	FY2015 Indice	Acq Cost (FY2015$)	BY04$ O&S Cost	FY2015$ O&S Costs	FY04$ Life Cycle Cost	FY2015$ Life Cycle Cost	QTY	Total Baseline LCC (FY04$)	Total Baseline LCC (FY2015$)
MPF(F) - (1)	$2,435,000,000	2008	1.0655	$2,285,221,709	1.2240	$2,797,049,601	$420,743,069	$514,978,143	$2,705,964,777	$3,312,027,744	1	$2,705,964,777	$3,312,027,744
MPF(F) - (2)	$1,865,000,000	2009	1.0869	$1,715,963,476	1.2240	$2,100,292,912	$364,433,704	$446,057,003	$2,080,397,181	$2,546,349,915	1	$2,080,397,181	$2,546,349,915
MPF(F) - (3)	$1,825,000,000	2010	1.1086	$1,646,235,265	1.2240	$2,014,947,466	$309,228,445	$378,487,258	$1,955,463,710	$2,393,434,724	1	$1,955,463,710	$2,393,434,724
MPF(F) - (4)	$1,825,000,000	2010	1.1086	$1,646,235,265	1.2240	$2,014,947,466	$309,228,445	$378,487,258	$1,955,463,710	$2,393,434,724	1	$1,955,463,710	$2,393,434,724
MPF(F) - (5)	$1,825,000,000	2011	1.1308	$1,613,956,142	1.2240	$1,975,438,692	$255,105,642	$312,242,410	$1,869,061,784	$2,287,681,102	1	$1,869,061,784	$2,287,681,102
MPF(F) - (6)	$1,825,000,000	2011	1.1308	$1,613,956,142	1.2240	$1,975,438,692	$255,105,642	$312,242,410	$1,869,061,784	$2,287,681,102	1	$1,869,061,784	$2,287,681,102
MPF(F) - (7)	$1,825,000,000	2012	1.1534	$1,582,309,943	1.2240	$1,936,704,600	$202,044,070	$247,296,480	$1,784,354,013	$2,184,001,080	1	$1,784,354,013	$2,184,001,080
MPF(F) - (8)	$1,825,000,000	2012	1.1534	$1,582,309,943	1.2240	$1,936,704,600	$202,044,070	$247,296,480	$1,784,354,013	$2,184,001,080	1	$1,784,354,013	$2,184,001,080
T-AOE	$358,229,844	2004	1.0000	$358,229,844	1.2240	$438,463,646	$1,194,170,756	$1,461,665,005	$1,552,400,599	$1,900,128,650	1	$1,552,400,599	$1,900,128,650
MV-22	$79,007,000	2004	1.0000	$79,007,000	1.2240	$96,702,432	$82,266,008	$100,693,593	$161,273,008	$197,396,026	48	$7,741,104,368	$9,475,009,238
CH-53X	$26,100,000	1981	0.4749	$54,953,661	1.2240	$67,261,796	$86,339,657	$105,679,740	$141,293,318	$172,941,536	20	$2,825,866,361	$3,458,830,717
SH-60R	$36,476,155	2004	1.0000	$36,476,155	1.2240	$44,645,827	$54,810,544	$67,088,106	$91,286,699	$111,733,934	12	$1,095,440,391	$1,340,807,207
AH-1Z	$20,150,096	2004	1.0000	$20,150,096	1.2240	$24,663,173	$40,035,941	$49,003,992	$60,186,037	$73,667,165	18	$1,083,348,674	$1,326,008,973
F-35 JSF	$81,292,796	2002	0.9774	$83,173,098	1.2240	$101,801,624	$66,749,670	$81,701,597	$149,922,769	$183,503,221	36	$5,397,219,681	$6,606,115,954
VTUAV	$1,800,000	2002	0.9774	$1,841,634	1.2240	$2,254,110	$1,289,147	$1,577,881	$3,130,781	$3,831,991	6	$18,784,685	$22,991,946
UH-1Y	$27,875,556	2005	1.0130	$27,517,824	1.2240	$33,681,073	$27,485,866	$33,642,701	$55,003,691	$67,323,774	9	$495,033,217	$605,913,963
LCAC	$24,574,247	2004	1.0000	$24,574,247	1.2240	$30,078,214	$20,376,056	$24,939,742	$44,950,303	$55,017,956	24	$1,078,807,272	$1,320,430,940
LCU(R)	$17,152,632	2004	1.0000	$17,152,632	1.2240	$20,994,357	N/A	N/A	$17,152,632	$20,994,357	2	$34,305,263	$41,988,715
										TOTAL:		$37,326,431,481	$45,686,837,773
												(BY04$)	(FY2015$)

Table C-1: 2015 Baseline Architecture Summary

C.2.1 Summary Model Variables

Table C-2 summarizes the variables and formulas that generate the data in Table C-1.

Variable	Symbol	Description	Calculations
Platform Type	P	The type of platform from the baseline composition.	N/A
Acquisition Cost	A	The open source acquisition cost. Each unit acquisition cost is a per unit cost that is assumed to include all procurement and acquisition cost components. Source reference data is located in Chapter 8.	N/A
Acq. Year	Y_A	The year the acquisition cost is based upon.	N/A
BY04 Indice	I_{2004}	The inflation indice valve as provided by the Naval Cost Analysis Division, used to normalize all costs to FY2004$.	N/A
Acq. Cost (BY04$)	A_b	The normalized acquisition cost to BY04$.	$A_b = A*I_{2004}$; $A_b = A/I_{2004}$
FY2015 Indice	I_{2015}	The inflation indice valve as provided by the Naval Cost Analysis Division, used to normalize all costs to FY2015$.	N/A
Acq. Cost (FY2015)	A_{15}	The normalized acquisition cost to FY2015.	$A_{15} = A_b * I_{2015}$
BY04$ O&S Cost	$O\&S_b$	The per unit annual O&S cost for each platform normalized to BY04$. Each year of O&S costs was normalized to BY04$ and summed for the total.	$O\&S_B = \sum(FY_n / I_{2015})$
FY2015$ O&S Costs	$O\&S_{2015}$	The per unit annual O&S cost for each platform normalized to FY2015$.	$O\&S_{2015} = (\sum FY_n)*I_{2015}$
FY04$ Life Cycle Cost	LCC_{04}	The Life Cycle Cost of each unit in FY04$.	$LCC_{04} = A_b + O\&S_b$
FY2015$ Life Cycle Cost	LCC_{15}	The Life Cycle Cost of each unit in FY2015$.	$LCC_{15} = A_{15} + O\&S_{2015}$
QTY	Q	The number of each platform in the 2015 Baseline Architecture.	N/A
Total Baseline LCC (FY04$)	T_b	The Life Cycle Cost of all platforms in the baseline composition in FY04$.	$Tb = LCC_{04} * Q$
Total Baseline LCC (FY2015$)	T_{2015}	The Life Cycle Cost of all platforms in the baseline composition in FY2015$.	$T_{2015} = LCC_{15} * Q$
Total	T	The total of the baseline composition in FY04$ and FY2015$.	$T = \sum T_b$; $T = \sum T_{2015}$

Table C-2: 2015 Baseline Architecture Summary Variables

C.2.2 Summary Model Calculation Example

To demonstrate the methodology utilized in the summary table, an example of how to generate the LCC for the lead MPF(F) is presented below.

Normalizing Acquisition Cost Data to BY04$:

$A_b = A/I_{2004}$

A_b = ($2,435,000,000 (FY08$)/(1.0655) = $2,285,221,709 (BY04$)

Normalizing Acquisition Cost Data from BY04$ to FY15$:

$A_{15} = A_b * I_{2015}$

A_{15} = ($2,285,221,709 (BY04$)) * (1.2240) = $2,797,049,601

Normalizing O & S Cost to BY04$: (From FY08 to FY04)

$O \& S_B = \sum(FY_n/I_{2015})$

$O \& S_B$ = ($60M(FY08$)/(1.065) + ($60M(FY09$)/(1.069) + ….. + ($60M(FY15))/(1.2240) = $420,743,069 FY04$

Normalizing O & S Cost To FY15$:

$O \& S_{2015} = (\sum FY_n)*I_{2015}$

$O \& S_{2015}$ = ($420,743,069 (FY04$)) * (1.2240) = $514, 978, 143 (FY15$)

Calculating FY04$ LCC:

$LCC_{04} = A_b + O \& S_b$

LCC_{04} = $2,285,221,709 (BY04$) + $420,743,069 (FY04$) = $2,705,964,777 (FY04$)

Calculating FY15$ LCC:

$LCC_{15} = A_{15} + O \& S_{2015}$

LCC_{15} = \$2,797,049,601 (FY15\$) + \$514, 978, 143 (FY15\$) = \$3,312,027,744 (FY15\$)

Calculating Total Baseline LCC (FY04$):

$Tb = LCC_{04} * Q$

Tb = \$2,705,964,777 (FY04\$) * 1 = \$2,705,964,777 (FY04\$)

Calculating Total Baseline LCC (FY15$):

$T_{2015} = LCC_{15} * Q$

T_{2015} = \$3,312,027,744 (FY15\$) * 1 = \$3,312,027,744 (FY15\$)

C.3 Acquisition Cost Methodology

To perform cost estimates for the acquisition costs of each component of the 2015 Baseline Architecture, three categories define the methodology:

Platforms that require an average procurement unit cost (APUC) calculation based on available open-source data

Platforms that only require cost normalization be performed

Platforms whose acquisition cost data is available in the FY05 President's Budget

The steps to compute the cost estimate for each category along with the 2015 Baseline Architecture components in each category follow.

C.3.1 APUC from Open-Source Data

Two components, the T-AOE and LCAC, of the 2015 Baseline Architecture have available cost data for each platform manufactured. Since it is unknown which individual

platforms might comprise the 2015 Baseline Architecture, the available cost data for each platform forms an average procurement unit cost (APUC). To demonstrate the methodology used, cost data for the T-AOE is provide in Table C-3. The table includes the year in which the cost was incurred, the acquisition cost of that year, what inflation indice was utilized, the normalized cost to FY04$, and the APUC.

	Acq. Cost	FY$ Index	FY04$ Cost
1987	$290,000,000	0.6976	$415,711,009.17
1989	$243,000,000	0.7487	$324,562,575.13
1990	$198,000,000	0.7787	$254,269,937.07
1992	$366,000,000	0.8349	$438,375,853.40
		Total: (FY04$)	$1,432,919,374.77
		APUC: (FY04$)	$358,229,843.69

Table C-3: T-AOE APUC Data.

C.3.2 APUC from Open-Source Data Model Variables

Table C-4 summarizes the variables and formulas used to calculate the data in Table C-3.

Variable	Symbol	Description	Calculations
Year	Y	Year T-AOE was procured.	N/A
Acq. Cost	A	Acquisition cost of the T-AOE, source reference data is located in Chapter 8.	N/A
FY$ Index	I_{2004}	The inflation indice valve as provided by the Naval Cost Analysis, used to normalize all costs to FY04$ (BY04$).	N/A
FY04$ Cost	A_b	The normalized acquisition cost to FY2004.	$A_b = A/I_{2004}$
Total (FY04$)	A_T	The total acquisition for all T-AOE's in 2004$.	$A_T = \sum A_b$
APUC	APUC	The average procurement unit cost for all T-AOEs.	$APUC = A_T/n$
Number of Platforms	n	The number of platforms included in the APUC calculation.	N/A

Table C-4: APUC Model Variables.

C.3.3 APUC from Open-Source Data Calculation Example

To demonstrate the methodology utilized to calculate the APUC, an example of how to calculate the APUC for the T-AOE is provided.

Normalizing Acquisition Cost per T-AOE to FY04$:

$$A_b = A/I_{2004}$$

A_b = \$290,000,000 (FY87\$)/0.6976 = \$415,711,009.17 (FY04\$)

A_b = \$243,000,000 (FY89\$)/0.7487 = \$324,562,575.13 (FY04\$)

(Methodology continues for other T-AOEs)

Calculating Total Acquisition Costs in FY04$:

$A_T = \sum A_b$

A_T = \$415,711,009.17 (FY04\$) + \$324,562,575.13 (FY04\$) + \$254,269,937.07 (FY04\$) + \$438,375,853.40 (FY04\$) =

\$1,432,919,374.77 (FY04\$)

Calculating T-AOE APUC:

$APUC = A_T/n$

APUC = \$1,432,919,374.77 (FY04\$)/4 = \$358,229,844 (FY04\$)

C.3.4 Acquisition Cost Data Normalization

Several components of the 2015 Baseline Architecture have open source cost data available that only require cost normalization. Such components include the MV-22, CH-53, VTUAV, and the MPF(F). To demonstrate the methodology utilized for normalization, Table C-5 illustrates an example of how to generate the MV-22 acquisition cost.

Acquisition Cost	Year	Index	BY04$ Index	BY04$ Cost	FY$ Index	FY15$
$79,007,000	2004	APN	1.0000	$79,007,000	1.2240	$96,702,432

Table C-5: MV-22 Acquistion Cost Data.

C.3.5 Acquisition Cost Data Normalization Model Variables

Table C-6 summarizes the variables and formulas used to calculate the data in Table C-5.

Variable	Symbol	Description	Calculations
Acquisition Cost	A	The open source acquisition cost value, source reference data is located in Chapter 8.	N/A
Year	Y	The year of the acquisition cost value.	N/A
Index	I	The type of inflation indice used. For this example, APN is the indice for aircraft procurement.	
BY04$ Index	I_{2004}	The inflation indice valve as provided by the Naval Cost Analysis Division, used to normalize all costs to FY04$ (BY04$).	N/A
BY04$ Cost	A_b	The normalized acquisition cost to FY04.	$A_b = A * I_{2004}$
FY$ Index	I_{2015}	The inflation indice valve as provided by the Naval Cost Analysis Division inflation calculator used to normalize all costs to FY15$.	N/A
FY15$	A_{15}	The normalized acquisition cost to FY15.	$A_{15} = A_b * I_{2015}$

Table C-6: Acquisition Cost Data Normalization Variables.

C.3.6 Acquisition Cost Data Normalization Calculation Example

To demonstrate the methodology utilized to normalize open-source cost data, an example of how to normalize the open-source acquisition cost data for the MV-22 is provided.

Normalizing Acquisition Cost Data to BY04$:

$A_b = A * I_{2004}$

A_b = $79,007,000(FY04$) * 1.000 = $79,007,000 (FY04$)

Normalizing Acquisition Cost Data from BY04$ to FY15$:

$A_{15} = A_b * I_{2015}$

A_{15} = $79,007,000 (FY04$) * 1.2240 = $96,702,432 (FY15$)

C.3.7 Acquisition Cost Data from FY05 Budget

Several components of the 2015 Baseline Architecture are future capabilities that have full funding in the FY05 President's Budget. These components include the SH-60R, AH-1Z, JSF, LCU(R), and UH-1Y. To demonstrate the methodology utilized for the normalization, Table C-7 provides the cost data used to generate the acquisition cost for the LCU(R).

	Total Program (FY04$)	FY15 Index	FY15$
Quantity	19		
End Cost	$324,500,000.00	1.2240	$397,179,228.6
Less Adv Procurement	$0.00	1.2240	$0.0
Less Escalation	$0.00	1.2240	$0.0
Full Funding TOA	$324,500,000.00	1.2240	$397,179,228.6
Plus Advance Procurement	$0.00	1.2240	$0.0
Total Obligation Authority	$324,500,000.00	1.2240	$397,179,228.6
Plus Outfitting and Post Delivery	$1,400,000.00	1.2240	$1,713,562.2
Plus Escalation	$0.00	1.2240	$0.0
Total Obligation Authority	$325,900,000.00	1.2240	$398,892,790.8
Avg. Unit End Cost	$17,152,631.58	1.2240	$20,994,357

Table C-7: LCU(R) Acquisition Cost.

C.3.8 Acquisition Cost Data from FY05 Budget Model Variables

Table C-8 summarizes the variables and formulas used to calculate the data in Table C-7.

Variable	Symbol	Description	Calculations
Total Program (FY04$)	T_{PA}	The total funded costing data for LCU(R) program.	N/A
FY15 Index	I_{2015}	The inflation indice valve as provided by the Naval Cost Analysis, used to normalize all costs to FY15$.	N/A
FY15$	A_{15}	The normalized acquisition cost to FY15.	$A_{15} = T_{PA} * I_{2015}$
Quantity	Q	The number of planned LCU(R) procurements.	N/A
End Cost	E_C	The projected end cost prior to additional cost requirements.	N/A
Less Adv Procurement	P_A	Authority provided in an appropriation act to obligate and disburse during a FY from the succeeding year's appropriation. This funds are added to the previous year's budget and deducted from the next year.	N/A
Less Escalation	E	The use of a index to convert past to present prices (normalize) previously spent program costs.	N/A
Full Funding TOA	TOA_1	The total program value less advance procurement and outfitting and post delivery costs.	$TOA_1 = E_C - P_A - E$
Plus Advance Procurement	P_A	Authority provided in an appropriation act to obligate and disburse during a FY from the succeeding year's appropriation. This funds are added to the previous year's budget and deducted from the next year.	N/A
Total Obligation Authority	TOA_2	Total program value plus advance procurement costs.	$TOA_2 = TOA_1 + P_A$
Plus Outfitting and Post Delivery	C_A	A cost that only applies to Navy ship building programs. Is the cost required to make a ship ready for delivery and accounts for unforeseen cost requirements.	N/A
Plus Escalation	E	The use of an index to convert past to present prices (normalize) previously sent program costs	N/A
Total Obligation Authority	TOA_T	Total program value.	$TOA_T = TOA_2 + C_A + E$
Avg. Unit End Cost	APUC	The average cost per unit of each planned ship procurement.	$APUC = TOA_T / Q$

Table C-8: LCU(R) Acquisition Cost Model Variables.

C.3.9 Acquisition Cost Data from FY05 Budget Calculation Example

The methodology utilized to calculate acquisition cost data from the FY05 Budget, is demonstrated in the following example using data from the LCU(R).

Normalizing Cost Data to FY15$:

$A_{15} = T_{PA} * I_{2015}$

A_{15} = $324,500,000.00 (FY04$) * 1.2240 = $397,179,228.6 (FY15$) (Same methodology for each cost element)

Calculating Full Funding TOA:

$TOA_1 = E_C - P_A – E$

TOA_1 = $324,500,000.00 (FY04$) - $0 - $0 = $324,500,000.00 (FY04$)

Calculating Total Obligation Authority:

$TOA_2 = TOA_1 + P_A$

TOA_2 = $324,500,000.00 (FY04$) + $0 = $324,500,000.00 (FY04$)

Calculating Total Obligation Authority for total program:

$TOA_T = TOA_2 + C_A + E$

TOA_T = $324,500,000.00 (FY04$) + $1,400,000 (FY04$) + $0 = $325,900,000.00 (FY04$)

Calculating APUC:

$APUC = TOA_T/Q$

APUC = $325,900,000.00 (FY04$)/19 = $17,152,631.58 (FY04$)

C.4 Operating and Support (O & S) Cost Methodology

For each 2015 Baseline Architecture component, the VAMOSC database values for O & S costs are primarily used to predict the historic and future O & S costs. Similar to the acquisition costing methodology, there are four categories of O & S cost estimates:

O & S predictions using only historical costs

O & S predictions using analogous systems with historical cost data

O & S predictions using the FY05 President's Budget

O & S data that only require cost normalization

Each category is described below along with the 2015 Baseline Architecture components in each category.

C.4.1 O & S Predictions Using Historical Data

To estimate the O & S cost data strictly from historical data, the VAMOSC database contains the necessary data to compute the costs for every component with the exception of the MPF(F), LCAC, LCU(R), and VTUAV. Table C-9 demonstrates the methodology used to calculate the O & S costs for the T-AOE.

Historic Avg. Ship Class O & S costs (from VAMOSC) for T-AOE				
Year	*O & S Cost (FY04$)*	*% Change from prior year*	*Absolute Avg. % change*	*Avg. O & S per year (FY04$)*
2003	$48,112,815	22.0697%	9.5801%	$37,493,939
2002	$37,494,467	-0.1635%		
2001	$37,555,780	12.3333%		
2000	$32,923,914	0.8775%		
1999	$32,635,019	4.5097%		
1998	$31,163,293	-17.9447%		
1997	$36,755,437	-13.1085%		
1996	$41,573,518	5.6341%		
1995	$39,231,205			
Total:	$337,445,448			
Future Avg Ship Class O & S Cost			**Past O & S Cost (for LCC)**	
Year	*FY04$*		*Year*	*O & S Cost (FY04$)*
2004	41,085,901		2003	$48,112,815
2005	45,021,976		2002	$37,494,467
2006	49,335,133		2001	$37,555,780
2007	54,061,495		2000	$32,923,914
2008	59,240,647		1999	$32,635,019
2009	64,915,968		1998	$31,163,293
2010	71,134,992		1997	$36,755,437
2011	77,949,805		1996	$41,573,518
2012	85,417,485		1995	$39,231,205
2013	93,600,576			
2014	102,567,618		Total:	$337,445,448
2015	112,393,712		FY15 Index	2015.0000
			FY15$	$679,952,577,720
TOTAL (FY04$)	$856,725,308	**Total O & S**	$1,048,631,776	FY2015$
FY15 Index	1.2240			

Table C-9: T-AOE O & S Predictions using Historical Data.

C.4.2 O & S Predictions Using Historical Data Model Variables

Table C-10 summarizes the variables and formulas used to calculate the data in Table C-9.

Variable	Symbol	Description	Calculations
Year	Y_H	The year in which historic O & S cost applies.	N/A
O&S Cost (FY04$)	$O\&S_{04}$	The historical O & S cost in FY04$ provided by VAMOSC.	N/A
% Change from Prior Year	$\Delta_{\%}$	The percentage O & S cost change observed for each year of historic data. This percentage change is beyond the annual increase due to inflation.	$\Delta_{\%} = 1 - (Y_{H2} / Y_{H1})$; $\Delta_{\%} = 1 - (Y_{H3} / Y_{H2})$; Etc.
Avg. % Change	$A_{\Delta\%}$	The average percentage O & S cost change based on number of years of available historic O & S cost data.	$A_{\Delta\%} = \sum ABSY_{Hn} / 8$
Avg. O&S per Year (FY04$)	$O\&S_{A04}$	The average O & S cost per year based on historical data across the T-AOE class in FY04$.	$O\&S_{A04} = \sum O\&S_{04} / N_y$
Years' Worth of Data	N_y	The number of years worth of O & S data from VAMOSC database.	N/A
Future Avg. Ship Class O & S Cost	--	The predicted future O & S cost per year up to 2015. Based on historical average and average annual percentage increase.	N/A
Year	Y_F	The future year up to 2015.	N/A
FY04$	$O\&S_{04(1,2,,,n)}$	The O & S cost in FY04$ for future year with average % change applied.	$O\&S_{04(1)} = O\&S_{04(1)} (1+ A_{\Delta\%})$; $O\&S_{04(2)} = O\&S_{04(2)} (1+ A_{\Delta\%})$; etc.
Total (FY04$)	$O\&S_{T04}$	The total O & S cost for the LCC from the years 1995 to 2015 in FY04$.	$O\&S_{T04} = \sum O\&S_{04}$
FY$ Index	I_F	The future year inflation indice valve as provided by the Naval Cost Analysis Division inflation calculator used to normalize all costs to FY15$.	N/A
Total O & S (FY2015$)	$O \,\&\, S_{F\$}$	The normalized O & S cost to FY2015	$O\&S_{F\$}.= O\&S_{T04} * I_F$

Table C-10: O & S Historical Calculation Variables.

C.4.3 O & S Prediction Using Historical Data Calculation Example

To demonstrate the methodology utilized to calculate O & S costs based on historic cost data, an example of how the O & S costs for the T-AOE are calculated follows.

Calculating the annual percentage change of the historical cost data:

$\Delta_{\%} = 1 – (Y_{H2}/Y_{H1})$; $\Delta_{\%} = 1 - (Y_{H3}/Y_{H2})$; etc.

$\Delta_{\%} = 1 – (\$77.4M/\$48.1M) = 22\%$

$\Delta_{\%} = 1 – (\$37.5M/\$37.4M) = -.16\%$

$\Delta_{\%} = 1 – (\$32.9M/\$37.5M) = 12.33\%$

$\Delta_{\%} = 1 – (\$32.6M/\$32.9M) = .87\%$

$\Delta_{\%} = 1 – (\$31.1M/\$32.6M) = 4.5\%$

$\Delta_{\%} = 1 – (\$36.7M/\$31.1M) = -17.9\%$

$\Delta_{\%} = 1 – (\$41.5M/\$36.7M) = -13.10\%$

$\Delta_{\%} = 1 – (\$39.2M/\$41.5M) = 5.63\%$

Calculating the average annual percentage change:

$A_{\Delta\%} = \sum ABSY_{Hn}/8$

$A_{\Delta\%} = 76.6\%/8 = 9.58\%$

Calculating the average historical O & S cost per year (FY04$):

$O\&S_{A04} = \sum O\&S_{04}/9$

$O\&S_{A04} = \$337,445,448/9 = \$37,493,939$ (FY04$)

Calculating future year O & S cost predications:

$O\&S_{04(1)} = O\&S_{04(1)}\ (1+ A_{\Delta\%})$; $O\&S_{04(2)} = O\&S_{04(2)}\ (1+ A_{\Delta\%})$; etc.

$O\&S_{04(1)} = \$37,493,939$ (FY04$) * (1 + .0958) =
$41,085,901 (FY04$) (Prediction for 2004)

$O\&S_{04(2)} = \$41,085,901$ (FY04$) * (1 + .0958) =
$45,021,976 (FY04$) (Prediction for 2005)

$O\&S_{04(3)} = \$45,021,976$ (FY04$) * (1 + .0958) =
$49,335,133 (FY04$) (Predication for 2006);

Continues until 2015:

Normalizing O & S Cost Data to FY2015$:

$O\&S_{F\$} = O\&S_{T04} * I_F$

$O\&S_{F\$} = \$1,194,170,756$ (FY04$) * 1.2240 = $1,461,665,005

C.4.4 O & S Predictions Using Analogous Systems

Generating the O & S costs for several systems requires the use of analogous systems to complete the estimation. The following platforms, along with their analogous system, require using an analogy approach:

2015 Baseline Component	Analogous System
JSF	F/A-18F
MV-22	AV-8B; EA-6B; F-14D; F/A-18E
SH-60R	SH-60B
AH-1Z	AH-1W
VTUAV	AF Predator
UH-1Y	UH-1N
CH-53X	CH-53E

Table C-11: Analgous Systems.

In addition to analogies, several platforms require the use of cost factors. For the cost factor, assume the JSF and the UH-1W will require a 5% increase of O & S support over its analogous system. This becomes the cost factor. Also, the CH-53X will have a 25% decrease in O & S costs over its analogous system once the system reaches deployment. To demonstrate the methodology used to estimate the O & S costs for this category, the cost data of the JSF is in Table C-12.

O & S Costing							
Historic O&S costs (from VAMOSC) for F/A-18F - used as analogous system							
Year	O & S Cost (FY04$)	# of Aircraft	O & S Cost per A/C (FY04$)	% Change from Prior Year	Absolute Avg. % Change	Avg. O & S per Year (FY04$)	Predicted O & S (5% Greater)
2003	$160,539,602	69	$2,326,661		20.28%	$1,712,451	$1,798,074
2002	$90,031,869	47	$1,915,572	20.28%			
2001	$41,230,519	27	$1,527,056	**42.13%**	(Considered an outlier and excluded)		
2000	$11,488,698	13	$883,746	NA			
1999	$7,636,887	4	$1,909,222				
Future Avg. Aircraft O&S Cost							
Year	FY04$						
2004	$1,798,074						
2005	$2,162,758						
2006	$2,601,408						
2007	$3,129,025						
2008	$3,763,652						
2009	$4,526,994						
2010	$5,445,157						
2011	$6,549,542						
2012	$7,877,917						
2013	$9,475,713						
2014	$11,397,573						
2015	$13,709,224						
Total (FY04$)	$72,437,038	Total O & S	$88,662,935	FY15$			

Table C-12: O & S Prediction for JSF.

C.4.5 O & S Predictions Using Analogy and Cost Factor Model Variables

Table C-13 summarizes the variables and formulas used to calculate the data in Table C-12.

Variable	Symbol	Description	Calculations
Year	Y_H	The in which historic O & S cost applies.	N/A
O & S Cost (FY04$)	$O\&S_{04}$	The historical O & S cost in FY04$ provided by VAMOSC.	N/A
# of Aircraft	Q_{AC}	The number of aircraft included in the O & S cost data as reported in VAMOSC.	N/A
O & S Cost per A/C (FY04$)	$O\&S_{AC}$	The allocated O & S cost per aircraft in FY04$.	$O\&S_{AC} = O\&S_{04}/Q_{AC}$
% Change from Prior Year	$\Delta_{\%}$	The percentage O & S cost change observed for each year of historic data. This percentage change is beyond the annual increase due to inflation.	$\Delta_{\%} = 1 - (Y_{H2}/Y_{H1})$; $\Delta_{\%} = 1 - (Y_{H3}/Y_{H2})$; etc.
Avg. % Change	$A_{\Delta\%}$	The average percentage O &S cost change based on number of years of available historic O & S cost data.	$A_{\Delta\%} = \sum Y_{Hn}/5$
Avg. O & S per Year (FY04$)	$O\&S_{A04}$	The average O & S cost per year based on historical data across the F/A-18F in FY04$.	$O\&S_{A04} = \sum O\&S_{04}/5$
Predicted O & S (5% Greater)	$O\&S_{CF}$	It was assumed the JSF would require 5% more O & S support than the F/A-18F. This 5% cost factor was added to the average O&S per year.	$O\&S_{CF} = O\&S_{A04} * (1+.05)$
Future Avg. Aircraft O & S Cost		The predicted future O & S cost per year up to 2015. Based on historical average and average annual percentage increase.	N/A
Year	Y_F	The future year up to 2015.	N/A
FY04$	$O\&S_{04(1,2,,,n)}$	The O & S cost in FY04$ with cost factor applied for future year with average % change applied.	$O\&S_{04(2)} = O\&S_{04(1)} (1+ A_{\Delta\%})$; $O\&S_{04(3)} = O\&S_{04(2)} (1+ A_{\Delta\%})$; etc.
Total (FY04$)	$O\&S_{T04}$	The total O & S cost for the LCC from the years 1995 to 2015 in FY04$.	$O\&S_{T04} = \sum O\&S_{04}$
FY$ Index	I_F	The future year inflation indice valve as provided by the Naval Cost, used to normalize all costs to FY15$.	N/A
Total O & S (FY15$)	$O\&S_{F\$}$	The normalized O & S cost to FY15.	$O\&S_{F\$} = O\&S04_{(1,2,,,n)} * I_F$

Table C-13: O & S Prediction for JSF Variables.

C.4.6 O & S Predictions Using Analogy and Cost Factors Calculation Example

The calculations performed during this section are identical to the steps taken in Section 2.3.3 with the exception of the application of the 5% cost factor. The example below demonstrates the use of the cost factor for the JSF.

Predicting future O & S costs (FY04$) for the JSF using a cost factor and analogous historical cost data:

$$O\&S_{CF} = O\&S_{A04} * (1+.05)$$

$$O\&S_{CF} = \$1{,}712{,}451\ (FY04\$) * (1+.05) = \$1{,}798{,}074\ (FY04\$)$$

C.4.7 O & S Predictions Using FY05 Budget Data

Cost data from the FY05 President's Budget O & S cost data is used to determine the O & S costs for the LCAC and VTUAV. For the VTUAV, the USAF Predator is the analogous system. VAMOSC does not track the historic cost of the LCAC. However, any cost that is incurred after production is classified as an O & S cost. The LCAC is currently undergoing a Service Life Extension Program (SLEP). The President's Budget contains the costs for the SLEP. Table C-14 displays the cost data.

	Total Program (FY04$)
Quantity	71
End Cost	$1,368,600,000
Less Advance Proc	$27,900,000
Less FY03 Transfer	$1,500,000
Less Escalation	$0
Full Funding TOA	$1,339,200,000
Plus Advance Proc	$27,900,000
Plus Transfer Cost	$1,500,000
Total Obligation Authority	$1,368,600,000
Plus Outfitting and Post Delivery	$78,100,000
Plus Escalation	$0
Total	$1,446,700,000
Unit Cost (Avg. End Cost)	$20,376,056
2015 Index	1.2240
FY15$	$24,939,742

Table C-14: O & S Budget Cost Data for LCAC.

C.4.8 O & S Predictions Using FY05 Budget Data Variables

Table C-15 summarizes the variables and formulas used to calculate the data in Table C-14.

Variable	Symbol	Description	Calculations
Total Program (FY04$)	T_{PA}	The total funded costing data for LCAC SLEP program.	N/A
Quantity	Q	The number of planned LCAC programmed for SLEP	N/A
End Cost	E_C	The projected end cost prior to additional cost requirements.	N/A
Less Adv Procurement	P_A	Authority provided in an appropriation act to obligate and disburse during a FY from the succeeding year's appropriation. This funds are added to the previous year's budget and deducted from the next year's budget.	N/A
Less FY03 Transfer	T_{03}	The funding spent in FY03.	N/A
Less Escalation	E	The use of a index to convert past to present prices (normalize) previously sent program costs.	N/A
Full Funding TOA	TOA_1	The total program value less advance procurement and outfitting and post delivery costs.	$TOA_1 = E_C - P_A - T_{03} - E$
Plus Advance Procurement	P_A	Authority provided in an appropriation act to obligate and disburse during a FY from the succeeding year's appropriation. This funds are added to the previous year's budget and deducted from the next year's budget.	N/A
Plus Transfer Cost	T_Y	The costs expended in previous years.	N/A
Total Obligation Authority	TOA_2	Total program value plus advance procurement costs.	$TOA_2 = TOA_1 + T_Y + P_A$
Plus Outfitting and Post Delivery	C_A	This cost only applies to Navy ship building programs. It is the cost required to make a ship ready for delivery and accounts for unforeseen cost requirements.	N/A
Plus Escalation	E	This is the use of an index to convert past to present prices (normalize) previously sent program costs.	N/A
Total	TOA_T	Total program value.	$TOA_T = TOA_2 + C_A + E$
Unit Cost (Avg. End Cost)	APUC	The average cost per unit of each planned LCAC SLEP.	$APUC = TOA_T / Q$
FY2015 Index	I_{2015}	The inflation indice valve as provided by the Naval Cost Analysis Division inflation calculator used to normalize all costs to FY15$.	N/A
FY15$	A_{15}	The normalized acquisition cost to FY15.	$A_{15} = APUC * I_{2015}$

Table C-15: LCAC O & S Variables.

C.4.9 O & S Predictions Using FY2005 Budget Data Calculation Example

Calculating the O & S cost of the LCAC from the Budget only requires the normalization of data. Previous examples demonstrate the necessary actions.

Appendix D: WarGaming Results/Insights

D.1 Introduction

Wargaming has "probably existed as long as war itself."[438] The purpose of wargaming is to add insight into strategy, plans, and tactics that can be used on the battlefield and in other military maneuvers. Systems Engineering and Analysis Cohort Six (SEA-6) uses a wargame to gather further insights and to increase campus-wide collaboration in their Seabasing and Joint Expeditionary Logistics (JELo) project. SEA-6 students and students from the Naval Postgraduate School (NPS) Joint Wargaming Analysis Class (OA 4604), consisting mainly of students from the Operations Research and Operational Logistics curricula, conducts a wargame set in the year 2016 against the near-peer competitor, Peoples Republic of China (PRC). Use of the Joint Conflict and Tactical Simulation (JCATS) model allows the participants to engage in real-time "personnel-in-the-loop" decision making. This facilitates the examination of a Sea Base and its associated logistics from a different perspective in order to gain insights and re-challenge assumptions.

In the wargame, the Sea Base is considered a center of gravity (COG) by both the Blue and Red forces. Wargame results produce two major insights; the need to secure lines of communications (LOCs), particularly the survivability of the Maritime Propositioning Force (Future) (MPF(F)) ships, and the incompatibility of re-supplying non-expeditionary forces with certain joint equipment through the Sea Base.

D.2 Scenario: China – Philippine in 2016

Following China's integration into the World Trade Organization (WTO) in 2001, her economy continues its rapid growth from the 20th Century's last ten years. In addition to enhancing educational and social programs, the PRC invests its funds in military forces, focusing on strategic and naval forces capable of establishing a greater "sphere of influence" from its shores. In 2012, Taiwan and China sign a treaty formally recognizing each party's government and they set a timetable for unification by 2018.

[438] Peter O. Perla, *The Art of Wargaming*, (Naval Institute Press: Annapolis, MD: 1990), p. 1.

The growth of strategic and naval forces is seen by China as a strategic necessity to affirm rights to the offshore oil reserves in the South China Sea. Justifying through historical rights and economic requirements, in 2015 China publicly claims hegemony over the entire South China Sea and guarantees the freedom of innocent merchant shipping through its economic zone. That same year, the Peoples Liberation Army (PLA) Navy (PLAN) reinforces its presence in the Spratly Islands (especially on Mischief and Alison Reef) by creating three paved runways, pier and maintenance facilities, air defense artillery (ADA) batteries, and by installing ballistic missile sites. The Philippines, Vietnam, Indonesia, Malaysia, Australia, Singapore, Japan, and the United States all condemn China's announcement and the Spratly development, but fall short of consensus on a combined response. Indonesia, Malaysia and the Philippines, however, do form a hasty common defense treaty and again protest China's aggressive behavior in the area. The United States and Philippines had established a similar treaty in 2010.

China increases its naval presence in the South China Sea by deploying ships and aircraft from its northern fleets to augment the South Sea (Naihai) Fleet (SSF). Despite repeated protests, Chinese naval exercises frequently disregard the territorial seas of the Philippines, Malaysia and Indonesia. Early in 2016, a Philippine military jet, after being warned to clear, strafes a Chinese destroyer that fires its gun within two miles of Palawan Island's coast (Philippines). The Chinese destroyer returns fire but fails to hit the aircraft. Ten Chinese sailors die in the attack.

Two months later, claiming self-defense and the need to establish a "safety" perimeter around the South China Sea, the PRC invades Kepulalian Natuna, Indonesia with a division of Chinese infantry supported by an air defense regiment, and 10 shore-based, anti-ship missile batteries. They further threaten to invade Palawan Island (Philippines) if any of the Association of Southeast Asian Nations (ASEAN) nations react. In coordination, the PLAN sets up a quarantine of Puerto Princesa port (Palawan). The PRC government immediately calls for a treaty with the Philippines and

Indonesia to establish a New Era of South China Sea Cooperation among perimeter nations.

Led by the United States, ASEAN nations condemn China's action and submit a joint United Nations (UN) resolution to establish sanctions against the PRC. The Security Council vetoes this resolution. The President of the United States, through the Secretary of Defense (SECDEF), directs Commander Pacific Command (PACCOM) to establish a Combined Joint Task Force (CJTF) SEA TIGER with Indonesia, Philippines, Singapore, and Australia in order to prepare alternative courses of action to deter Chinese aggression and protect Philippine and Indonesian sovereignty. If deterrence fails, the CJTF Commander must prepare to repel an invasion of Palawan Island with follow-on operations to re-establish Indonesian sovereignty over Kepulalian Natuna. Strikes on the Chinese mainland or Taiwan require prior approval.

Allied cooperation is a necessity. With the decommissioning of USS KITTY HAWK, no conventional carrier is available to replace her in Japan. Instead, a Naval Expeditionary Strike Group composed of two 80,000-ton Expeditionary Warfare (EXWAR) Ships (Yokosuka), 2 LPD-17s (Sasebo), 5 LCS (Sasebo), 2 older Aegis CGs (Theater Ballistic Missile Defense (TBMD) capable), and 3 DDGs (not TBMD capable) remain forward-deployed in Japan along with 1 Marine Expeditionary Unit (MEU)-sized Marine force in Okinawa. The amphibious lift for these Marines comes from the EXWAR ships and LPD-17s in Japan. All other United States forces, including those in Korea, withdraw to the United States and make up an Expeditionary Force.

Time is critical as the PLA continues to reinforce their invasion forces, mobilize forces to invade Pawalan, and build world support for their actions. Figure D-1 shows the initial force disposition of Allied and PRC forces in the South China Seas Region.

Figure D-1: Initial Force Locations of Allied and PRC Forces.

In the wargame, CJTF SEATIGER will have the assets and capabilities of SEA-6's 2015 Baseline Architecture (2015 BLA) discussed in detail in Chapter 5 of this Technical Report. The MPF(F) will be located at the Forward Logistics Site (FLS) which, in this scenario, is Apra Harbor, Guam. The area of operations for the Sea Base will consist of Palawan Island and the Sulu Sea. The Joint Expeditionary Brigade (JEB) onboard the Sea Base is used as a deterrent force against PRC aggression. If the PRC does invade Palawan, the JEB will remove the PRC from Palawan.

D.2.1 Methodology

In this wargame, the students use many of the techniques taught by the Naval War College Program, Monterey, in the Joint Maritime Operations (NW 3275 & NW 3276) classes. A specific technique involves the Joint Operation Planning and Executing System (JOPES) to develop the Commander's Estimate of the Situation (CES) for the

game. Another technique is course of action (COA) development. Two COAs are developed and analyzed based on principles of war, operational art, risk, timing, infrastructure damage and force protection. The most likely COA scenario is selected and variables associated to it are entered in JCATS. The simulation is conducted and results analyzed to identify patterns and outcomes.

JCATS is a self-contained, high-resolution joint simulation model managed by the Joint Warfighting Center at U.S. Joint Forces Command. It is used for training, exercises, analysis, experimentation, mission planning and rehearsals. JCATS provides multisided air, ground and sea combat models in a digitized terrain.

Two competing teams, the Blue Team representing the United States and Coalition partners, and the Red Team representing the PRC, are formed. SEA-6 participants serve as Logistics and Materiel (J-4) staff on the Blue Team and provide input related to supply, maintenance, attrition rates, and tonnage lift capacity as well as combat service support operations in the area of operations (AO).

D.2.2 Wargaming Insights

The wargame demonstrates the need to secure LOCs, and the vulnerability of the MPF(F) as it transits from the FLS to the AO. Although the exploration of vulnerability is out of scope in this study, the wargame shows that a thoughtful enemy with blue-water capability is a definite threat to the MPF(F). This highlights a need for MPF(F) escort vessels during its transit from the FLS to the AO. In the wargame, the Red Forces pre-stage their 20 diesel submarines on the MPF(F)s route from the FLS to the AO. Since the MPF(F) ship is only designed to commercial survivability standards instead of warship standards, the PRC submarines annihilate the unescorted MPF(F) ships during their transit. In addition to escorts, the MPF(F) may need to be designed with higher survivability.

Securing the LOCs also includes securing the FLS and airports of debarkation (APOD). The International Airport of Manila is an APOD in support of initial Army Airborne troops who are assigned to take the objective in this wargame. The PRC

sends fighters and tankers to the Manila airport to test the air defenses. The air defense corridors are able to kill the first wave of the PRC assault; however, bombers follow in the second wave after the majority of the air defenses are depleted. The Red Team annihilates the awaiting troops destined to proceed to the objective via air connectors.

The wargame also exposes another insight and possible gap in the Seabasing JELo system involving use of the Sea Base as a resupply node for non-expeditionary forces while simultaneously acting as a re-supply node for organic forces. SEA-6's study focuses primarily on the United States Marine Corps' 2015 Marine Expeditionary Brigade (MEB) to build the baseline architecture. In the wargame, the Sea Base is not a "stand alone" entity but is part of a larger force structure. One othe gaps exposed in the wargame involves the use of the Sea Base to resupply nonexpeditionary forces in the battlespace. In the scenario, Blue forces plan to place Patriot and Theater High-Altitude Area Defense (THAAD) batteries at the objective by air. Patriot and THAAD batteries are airlifted into theater to an APOD where the missiles are transported to the battery by truck. The missiles cannot be resupplied via helicopter due to the missile container design. If Red forces destroy the APOD at the objective, then Blue forces only have the remaining missiles at the battery. Resupplying the missile batteries requires one of the MPF(F) ships to transit back to the FLS and then transit back, taking it out of the AO for a significant period of time.

D.3 Alternative Uses for the Sea Base

During the planning phases of the wargame, the MPF(F) was shown to provide the Commander Joint Task Force a wider range of capabilities to increase his combat power. One possible COA that was not selected for use in the subsequent JCATS phase of the wargame involved using the MPF(F) to act as a deceptive force by feigning an invasion of Taiwan. The JEB poses a viable threat to the Red Forces in this COA. In the tabletop wargame,[439] the resulting Red action is to reposition the PLAN aircraft carrier (CV) near Taiwan. This prompts Blue forces to launch the organic Joint Strike Fighters

[439] A tabletop wargame was conducted prior to the JCATS wargame to examine the feasibility of the COAs.

(JSFs), embarked within the MPF(F), to attack the PLAN CV.[440] The 36 organic fifth-generation JSFs[441] are superior to the 39 fourth-generation fighters embarked on the PLAN's CV. This action weakens the PRCs regional air superiority near Palawan and highlights an alternative use of the Sea Base and its expeditionary forces.

D.4 Conclusion

The OA 4604 wargame allows players from both forces to interact with the Sea Base and its logistics system in an operational setting, providing additional insights and opportunities to challenge architecture design assumptions. The wargame results produce two major insights; the need to secure lines of communications (LOCs), particularly the survivability of the MPF(F) ships, and the incompatibility of resupplying nonexpeditionary forces with certain joint equipment through the Sea Base. Wargaming is a promising venue for gaining an understanding of the Sea Base and its logistics by providing insights on how future Seabased operations might be conducted. Additionally, it also allows for examination of the Sea Base in the context of a larger system of systems.

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440 The PLAN has determined that they will design and build an aircraft carrier of their own design. However based on research and historical analysis it is assumed that the PLAN carrier will resemble ex-Soviet designs. The assumption is that the PLAN carrier will resemble the never built Orel Ul'yanovsk Class in its capabilities and aircraft compliment.

441 Richard Aboulafia, "Rethinking U.S. Air Power," Aerospace America Online, March 2001, <http://www.aiaa.org/aerospace/Article.cfm?issuetocid=66&ArchiveIssueID=11> (12 November 2004).

Appendix E: High Speed Assault Connector

E.1 Overview

Appendix F summarizes the results of the Total Ship Systems Engineering (TSSE) design for a High Speed Assault Connector (HSAC) to meet the employment requirements for 2025 Joint Expeditionary Logistics. Full analysis and results are available in the TSSE Joint ACCESS Final Report.[442]

E.2 Purpose

Current amphibious transport technology, including Programs of Record, are unable to deliver the required two surface Battalion Landing Teams (BLTs) from the Sea Base to shore within the required 10 hrs. To meet this requirement, the TSSE project team designed a High Speed Surface Connector for operation to, within and from the Sea Base. This HSAC, designated the Joint ACCESS (Amphibious Combat Cargo Expeditionary Support Ship), is a self deployable, load-once, roll-on/roll-off, landing vessel with integrated combat systems for mission specific offensive capabilities and full spectrum self-defense.

E.3 Primary Characteristics

The Joint ACCESS is designed to operate from a Forward Logistics Site (FLS) that may be up to 2,000 NM from the designated Sea Base area of operations. As such, the Joint ACCESS is a substantially larger vessel than the typical connectors used by the Navy of 2004 (e.g., LCACs and LCUs). It is also designed to operate at greater speeds and with reduced manning from ships of similar size. The primary characteristics of the Joint ACCESS are listed in Table E-1.

[442] Total Ship Systems Engineering Team (2004), "Joint ACCESS: A High Speed Assault Connector for Amphibious Seabasing Operations and Joint Expeditionary Logistics," Naval Postgraduate School Technical Report, Monterey, CA, December 2004.

Overall Length	149 m
Overall Beam	49 m
Maximum Draft	4.5 m
Full Load Displacement	4966 LT
Light Ship Displacement	3124 LT
Metacentric Height	7 m
Maximum Speed	43 kts
Shaft Horsepower	78,000 HP
Cruise Range (at 34 kts)	2300 NM
Crew Compliment	66 persons

Table E-1: ACCESS Characteristics.

E.4 Capabilities

The HSAC leverages off advances in material and construction techniques to create a trimaran hull-form capable of beaching for offload of the embarked troops and equipment. For its primary mission of delivering the surface BLTs, the ACCESS has capabilities as listed in Table E-2.

Maximum Payload	800 LT
Combat Loaded Troop Berthing	260 troops
Cargo Area	2060 m^2
Onload Time (port facility)	4 hrs
Offload Time (SS1, beached)	2 hrs

Table E-2: ACCESS Primary Mission Capabilities.

Onload of equipment is via roll-on through the stern gate while moored in port as shown in Figure E-1. This same method could potentially be utilized at the Sea Base in acceptable sea states. The stern gate serves a secondary purpose of launching and recovering Expeditionary Fighting Vehicles (EFV) as shown in Figure E-2. A dozen Joint ACCESSs are needed to embark and employ the two surface BLTs.

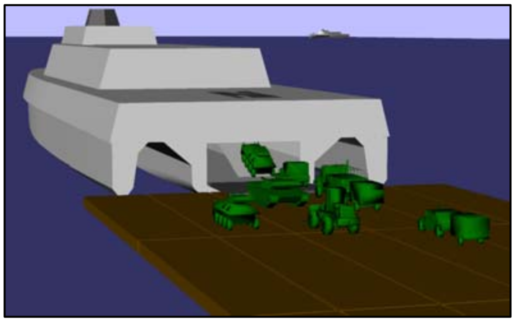


Figure E-1: Stern Gate Loading.

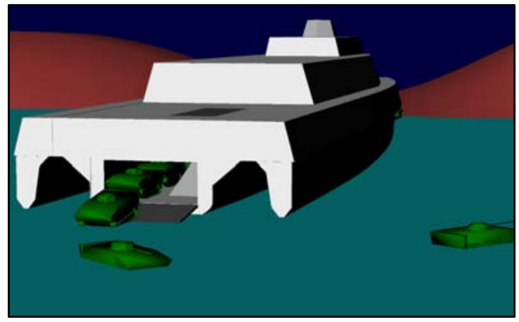


Figure E-2: EFV Launching.

The primary method for offloading cargo and equipment to the beach is via the extendable bow ramp and floating causeway system shown in Figures E-3 and E-4. This system supports the maximum simultaneous offload of two M1A1 Main Battle Tanks of to a maximum distance of 35 meters.

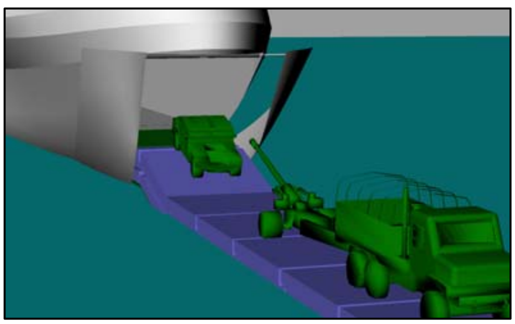


Figure E-3: Bow Doors Open.

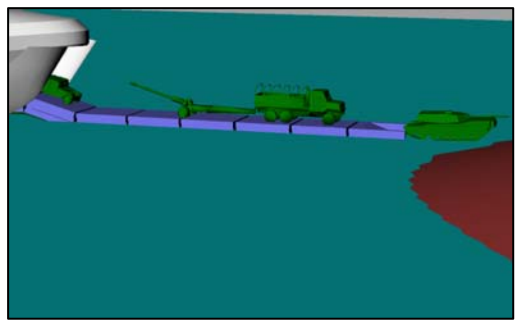


Figure E-4: Bow Ramp Offload.

The ACCESS flight deck is capable of handling rotary and Vertical Take Off and Landing (VTOL) aircraft including the MV-22, CH-53X, and SH-60R. Integrated hanger facilities are available for one SH-60R, while a flight deck elevator allows movement of cargo and equipment from the upper cargo deck to the flight deck. This elevator is designed to support the movement of vehicles up to a Light Armored Vehicle, from the cargo deck to the flight deck for further transfer via vertical lift assets. Additionally, it allows the transfer of additional SH-60Rs below decks when conducting secondary missions.

Joint ACCESS is multimission capable, primarily due to the modularity of the internal cargo deck (Figure E-5) and the available flight deck. Secondary missions

include Theater Support Vessel for resupply of logistics to the Sea Base, Humanitarian Assistance and Non-Combatant Evacuation Operations, Special Operations, and Unmanned Vehicle basing. TSSE Joint ACCESS Final Report describes the design process in detail.

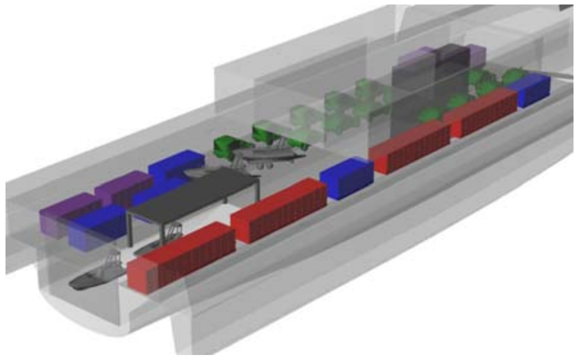


Figure E-5: Modularity of Cargo Deck.

Appendix F: Airlift Analysis: C-17 Globemaster III

F.1 Overview

As described in the Methodology portion of Chapter 1, the Joint Capabilities Integration and Development System (JCIDS) process emphasizes non-material solutions. This analysis evaluates the doctrine change of deploying the JEB purely by C-17 airlift, which assumes that there is a secure, C-17 compatible airfield available at the objective.

The C-17 Globemaster III is a multi-functional aircraft that is a crucial air transport element in military operations, and is the newest airlift aircraft to enter the Air Force's inventory. Specifically, the C-17 is capable of prompt strategic delivery of troops and all types of cargo to main operating bases or direct to forward deployment area bases. The aircraft is also able to perform theater airlift missions when required.

The C-17 measures 174 ft long with a 170-ft wingspan. Four Pratt and Whitney F117-PW-100 engines power the aircraft. Each engine has a thrust rating of 40,900 lbs. A crew of three operates the aircraft; this includes the pilot, copilot, and loadmaster. Cargo is loaded onto the C-17 through an aft door that accommodates military vehicles and palletized cargo. The C-17 can carry nearly all of the Army or Marine's air-transportable, combat equipment. The C-17 is also able to airdrop paratroopers and cargo.

Maximum cargo load capacity of the C-17 is 170,900 lbs, 172,200 lbs is maximum rolling stock load capacity and maximum gross takeoff weight is 585,000 lbs. The C-17 has unlimited range with in-flight refueling, and a cruise speed of 450 kts. This aircraft is able to operate on small, austere airfields; the C-17 can take off and land on runways as short as 3,000 ft and as narrow as 90 ft wide. Even on such narrow runways, the C-17 can turn around by using its backing capability while performing a tight 3-point turn.

This analysis determines how many aircraft trips or loads would be required to carry the Sea Based Maneuver Element (SBME), three Battalion Landing Teams (BLTs), to the objective (Southeast Asia). Additionally, the C-17 is also evaluated to determine the time it would take this asset to provide a Day of Supply (DOS) and a Day-and-a-Half of Supply, of the basic commodities of food, water, ammunition and fuel to forces in theater. This analysis assumes that a suitable airfield is available in the objective area.

The following discussion, consisting of C-17 characteristics analysis and transport capability calculations, provides an insightful look into this aircraft's potential for supporting the Joint Expeditionary Logistics (JELo) effort. Analysis is performed via evaluation of a C-17 Flight Limitations chart and aircraft dimension figures (Figure F-4 through 8), as well as C-17 characteristics.[443]

C-17 Characteristics:

- Max Range: Unlimited with in-flight refueling
- Empty Weight: 277,000 lbs
- Max Take-off Weight: 585,000 lbs
- Max speed: 450 kts
- Max Payload Capacity: 170,900 lbs for palletized cargo. Refer to load capacities for rolling stock, in the Flight Limitations chart
- Ramp Capacity: 40,000 lbs
- Fuel Capacity: 181,055 lbs or at 6.8 lbs/gal = approx. 26,626 gal
- Fuel usage: 19,643 lbs/hr[444] or at 6.8 lbs/gal = 2889 gal/hr
- Usable Cargo Floor Area (minus ramp): 1176 sq ft (65.33 ft long x 18 ft wide)
- Length: (784 in/12 in) = 65.33 ft
- Width: (216 in/12 in) = 18 ft
- Ramp Area: 357 sq ft (19.8 ft long x 18 ft wide)
- Length: (238 in/12 in) = 19.8 ft
- Width: (216 in/12 in) = 18 ft
- Total usable area (floor and ramp): 1533 sq ft
- Usable Volume: 10.2 ft high x 85.2 ft long (includes ramp) x 18 ft wide = 15,642 cu ft

[443] www.globalsecurity.org, [online database] (October 2004 [cited 03 December 2004]).
[444] U.S. Air Force, "U.S. Air Force Cost and Planning Factors," September 2002, in AFPAM 23-221, Fuel Logistics Planning, 01 May 98/AF1 65-503, (using 6.8 lbs/gal fuel conversion factor).

F.2 SBME Ground Vehicle/Helicopter Specifications[445] and C-17 Vehicle Load Capability

All calculations are based on individual SBME vehicle characteristics as per the MCCDC SBME Equipment Breakdown (Surface and Vertical lift).[446] The C-17 analysis uses area and rolling stock weight capacities to calculate total number of trips required.

The main vehicles and helicopters listed in Table F-1 and F-2 represent those items present in the SBME (surface and vertical-lifted vehicles and equipment). The full list of SBME vehicles/helicopters and their individual weight and area characteristics is delineated in Chapter 5. Percentages used in area and subsequent vehicle capacity calculations for each C-17 cargo bay floor section, are approximated from the C-17 Flight Limitations Chart.[447]

- Section I is 25% of floor area for Sections I-III (total area of 1,176 sq ft): .25 x 1,176 sq ft = 294 sq ft
- Section I max allowable weight: 70,000 lbs
- Section II is 65% of 1176 sq ft: .65 x 1,176 sq ft = 764 sq ft
- Section II max allowable weight: 172,200 lbs (if no other sections loaded)
- Section III is 10% of 1176 sq ft: .10 x 1,176 sq ft = 117 sq ft
- Max allowable weight for Section III: 38,000 lbs
- Section IV (ramp) area is 357 sq ft (19.8 ft long x 18 ft wide)
- Max allowable stationary weight for Section IV: 40,000 lbs

For the C-17 vehicle transport calculations, with respect to capability by weight and area, choose the lower of the two numbers for weight and area, as this is the limiting transport factor. If the vehicle capacity is the same by both weight and area, this is the value used. Table F-1 summarizes these calculations for the major vehicles.

445 www.globalsecurity.org, [online database] (October 2004 [cited 03 December 2004]).
446 MCCDC Concepts Branch Futures Division, "Baseline 2015 MEB," 24 January 2003, p. 37.
447 U.S. Army Air Mobility Command, C-17 Flight Limitations Chart, Figure 2-42, in Chapter 2, Air Mobility Command Aircraft, p 46; available on the World Wide Web @ http://www.globalsecurity.org/miitrsy/library/policy/army/fm/55-9/ch2.htm.

Vehicle Type	Quantity	Area (sq ft)	Weight (lbs)	Wheeled (W) or Tracked (T)	Number of Vehicles per C-17	Number of C-17 Trips Required	Load Time (minutes)
M1A1 Tank	28	506.8	141,075	W	1	28	45
EFV	106	360	72,879	T	2	53	76
LAV	84	200	31,103	W	5	17	190
LW-155	12	442	10,500	W	1	12	30
HIMARS	6	215	42,118	W	4	2	152
HMMWV	457	185	12,000	W	6	77	180
Contact Truck	18	214	21,300	W	5	4	150
LVS	36	333	50,500	W	2	18	76
Forklift	8	212	12,004	W	5	2	150
D7 Bulldozer	4	208	49,020	T	4	1	152
M88A2 Hercules Recovery Vehicle	4	341	141,173	T	1	4	45
MTVR	90	310	44,708	W	2	45	76
ABV	4	468	1,350	T	1	4	30
M60A1 AVLB	2	372	29,300	T	2	1	60
LSV	16	92.5	2,700	W	21	1	300
M9 ACE	8	264	53,800	T	3	3	114
Totals	883					272	

Table F-1: C-17 Transport Capability Table for Major End Items of the 2015 MEB SBME.

A C-17 transporting a M1A1 tank or M88A2 Hercules Recovery Vehicle will only be possible with less than maximum C-17 fuel capacity. The C-17 cannot exceed maximum takeoff weight of 585,000 lbs (can only take 166,925 lbs of fuel). More C-17s will be required, and in-flight refueling will need to occur, to ensure all tanks get to the objective. A total of 272 C-17 trips are required to transport SBME Ground vehicles and equipment to the objective.

For the C-17 helicopter transport calculations, with respect to capability by weight and area, choose the lower of the two numbers for weight and area, as this is the limiting transport factor. If the aircraft capacity is the same by both weight and area, this is the value used. Table F-2 summarizes these calculations for the helicopters.

Helicopter Type	Quantity	Area (sq ft)	Weight (lbs)	Number of Helicopters per C-17	Number of C-17 Trips Required
CH-53	20	661.5	36,336	1	20
UH-1Y	9	627	11,836	1	9
AH-1	18	500.5	10,216	1	18
SH-60	10	410	13,650	1	10
Totals	57				57

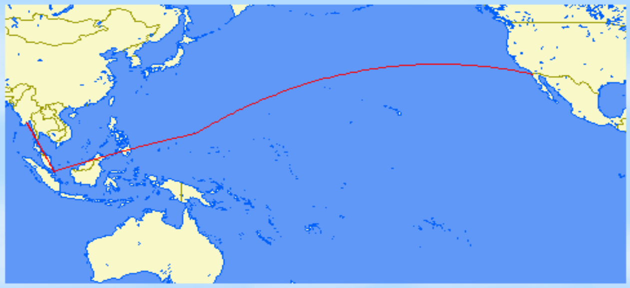
Table F-2: C-17 Transport Capability Table for Helicopters of the 2015 MEB Air Combat Element.

Combining the 272 C-17 trips for the vehicles with the 57 C-17 trips for the helicopters yields a total of 329 C-17 trips required to transport all helicopters and vehicles to the objective. As a comparison with other future force concepts, the Army states that it will take 350 C-17 sorties[448] to get the Stryker Brigade to the objective. No separate C-17 transport time calculations were done for these Stryker Brigade loads.

F.3 Time to Get Entire SBME (Ground Vehicles and Helicopters) to the Objective

For the following C-17 transport time calculations, 329 C-17 total trips were required to get entire SBME to objective, including all ground vehicles and helicopters. The C-17 flight route used in transporting these loads from San Diego (CONUS) to Guam to Singapore to the objective (Burma) is shown in Figure F-1. The first set of trips from San Diego and Okinawa will be helicopter loads to allow for helicopter buildup.

[448] Department of the Army, “Joint Military operations” brief, 26 August 2004, Slide 32.



From	To	Distance	Time
SAN (32°44'01"N 117°11'23"W)	GUM (13°29'00"N 144°47'46"E)	5369 nm	11:56
GUM (13°29'00"N 144°47'46"E)	SIN (01°21'21"N 103°59'15"E)	2533 nm	5:38
SIN (01°21'21"N 103°59'15"E)	RGN (16°54'26"N 96°08'00"E)	1039 nm	2:18
Total:		8941 nm	19:52

Code	Source	Location
GUM	FAA	Agana [Guam Intl], GU, US
RGN	DAFIF	Yangon (Rangoon) [Intl], MM
SAN	FAA	San Diego [Intl], CA, US
SIN	DAFIF	Singapore [Changi Intl Airport], SG

Figure F-1: C-17 Flight Path from San Diego to Objective.[449]

F.3.1 Equipment Transport Times (San Diego to Objective)

The load time for equipment is based on the average load time[450] for 1 M1A1 tank (45 minutes) and 1 HUMVEE truck (30 minutes). Average load time per vehicle calculates to 38 minutes. From this calculation, an average load time per C-17 is approximately 2 hrs.

The aircraft transit time from San Diego to Guam to Singapore to the objective (w/ 3 in-flight refueling) covers 20.5 hrs at a range of 8,872 NM. The total C-17 roundtrip time from San Diego to the objective will take approximately 45 hrs.

Currently, 120 C-17[451] aircraft are in active inventory. For different numbers of aircraft below, assume all aircraft launch and recover the same day and that airfield can process all aircraft the same day. This is an unrealistically optimistic assumption, but provides a "best-case" boundary. For 20 C-17s leaving at the same time from San Diego,

[449] Great Circle Website, Website distance calculations, available on the World Wide Web @ http://gc.kls2.com.
[450] Timothy R. Wakefield, MSgt, AMC/A37VG, e-mail discussion over equipment load times, Timothy.Wakefield@scott.af.mil.
[451] Boeing Corporation, C-17 production data, available on the World Wide Web @ http://www.globalsecurity.org/military/systems/aircraft/c-17-prod.htm.

16 round-trips are required. The total time requirement for 20 C-17s to get all loads to objective is 31 days. For 50 C-17s leaving at the same time from San Diego, 7 roundtrips are required. The total time requirement for 50 C-17s to get all loads to the objective is 14 days.

To get the SBME to the objective within the 10-day (240-hr) requirement, it will take 55 C-17 aircraft. However, with assuming 70% C-17 availability, 72 aircraft will actually be required to carry out this task. In order to see a trend in performance per aircraft quantity, a few additional transport calculations are made. For 100 C-17s leaving at the same time from San Diego, 4 round-trips are required. The total time requirement for 100 C-17s to get all loads to the objective is 8 days. For 150 C-17s leaving at the same time from San Diego, 3 round-trips are required. The total time requirement for 150 C-17s to get all loads to the objective is 6 days. Finally, for 200 C-17s leaving at the same time from San Diego, 2 round-trips are required. The total time requirement for 200 C-17s to get all loads to the objective is 4 days. Figure F-2 shows a comparison between the number of C-17 trips with the amount of time to complete the closure phase of operations.

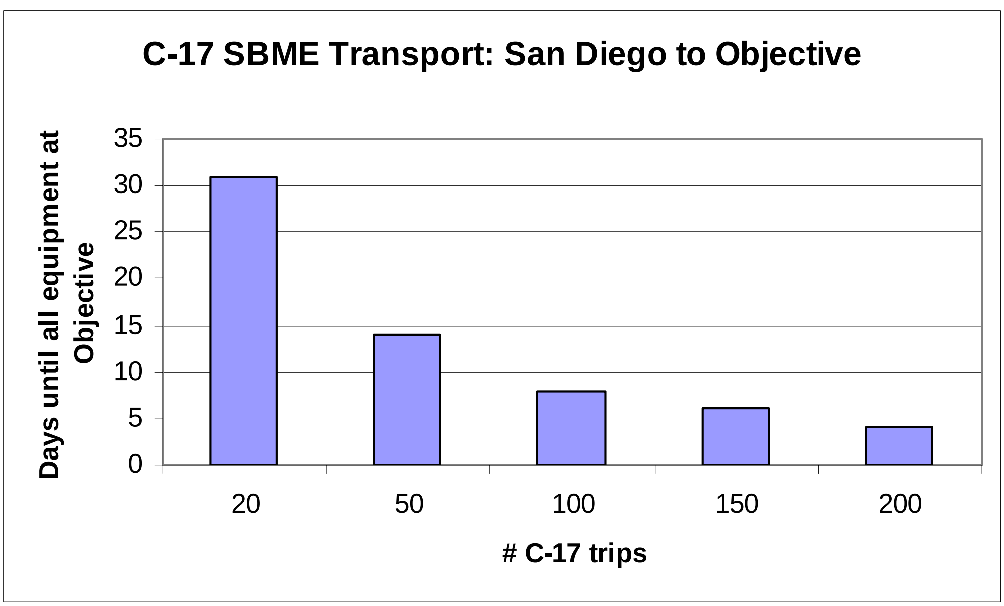


Figure F-2: C-17 SBME Transport Time Between San Diego and the Objective (Burma).

F.3.2 Equipment Transport Times (Okinawa to Objective)

The calculations are repeated for the case of a Marine Expeditionary Brigade (MEB) being garrisoned in Okinawa vice Camp Pendleton. Using the same assumptions as in calculations from San Diego, C-17 transit time from Okinawa to Singapore to the objective takes 9 hrs at a range of 4,000 NM. The total round-trip time per C-17 is 22 hrs.

For 20 C-17s leaving at the same time from Okinawa, 16 round-trips are required. The total time requirement for 20 C-17s to get all loads to the objective is 15 days. For 50 C-17s leaving at the same time from Okinawa, 7 round-trips are required. The total time requirement for 50 C-17s to get all loads to the objective is 7 days.

To get the SBME to the objective within the 10-day (240-hr) requirement, it will take a total of 30 C-17 aircraft. However, with assuming 70% C-17 availability, 39 aircraft are required to carry out this task. In order to see a trend in performance per aircraft quantity, a few additional transport calculations are made.

For 100 C-17s leaving at the same time from Okinawa, 4 round-trips are required. The total time requirement for 100 C-17s to get all loads to the objective is 4 days. For 150 C-17s leaving at the same time from Okinawa, 3 round-trips are required. The total time requirement for 150 C-17s to get all loads to the objective is 3 days. Finally, for 200 C-17s leaving at the same time from Okinawa, 2 round-trips are required. The total time requirement for 200 C-17s to get all loads to the objective is 2 days. Figure F-3 shows a comparison between the number of C-17 trips with the amount of time to complete the closure phase of operations.

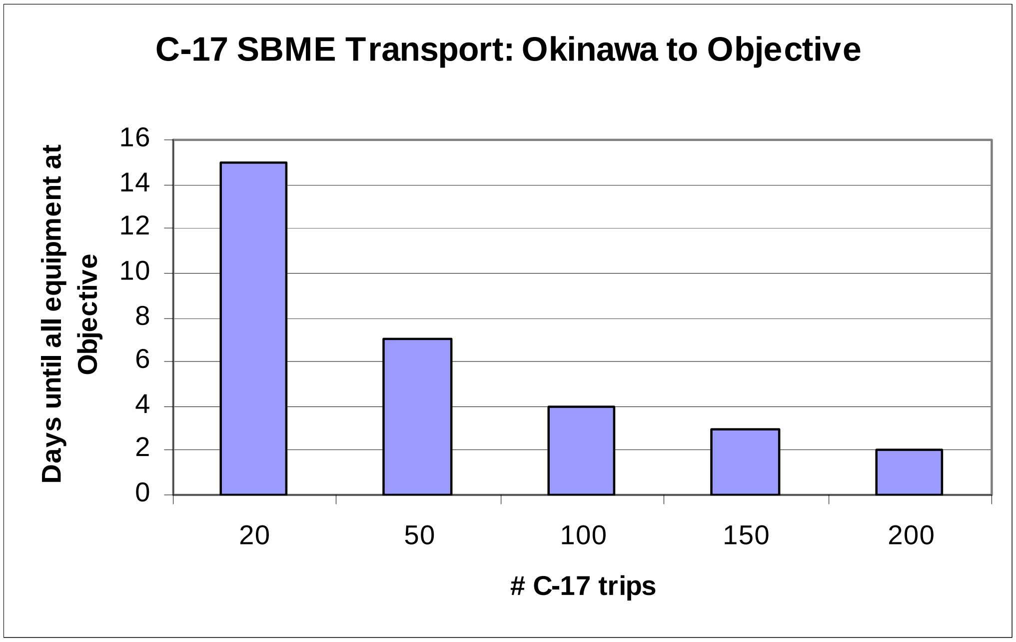


Figure F-3: C-17 SBME Transport from Okinawa to the Objective (Burma).

F.4 Sustainment Phase

One Day of Supply (DOS) for the troops ashore is equal to 767 short tons (1,534,000 lbs). This value is derived in Chapter 6 [2015 Joint Expeditionary Logistics Baseline Architecture Reliability, Availability and Maintainability Analysis]. Using the C-17 maximum palletized cargo load capacity of 170,900 lbs, 9 C-17 trips are required to get 1 DOS to the objective. If C-17s are used to resupply the object, the same transit calculations as in section F.3 apply. It will take 22.5 hrs for 9 C-17s to make this one-way transit.

The C-17s do not simultaneously launch for sustainment phase of operations. In order to stagger the arrival of aircraft, each C-17 needs to launch approximately every 2 hrs to disperse the 9 aircraft over a 24-hr period. It is also assumed that at least a 24-hr lead-time is needed due to the long transit time. Assuming 70% availability per C-17, 12 aircraft will be needed to achieve one DOS delivery. This is 10% of the current active C-17 fleet. Similarly, to get 14 C-17 loads (1 1/2 DOS) to the objective within 24 hrs, a 1 hr and 40 minute arrival schedule is needed. Similarly, assuming 70% availability per C-17, 19 aircraft will be needed to achieve 1 1/2 DOS delivery. This

is 16% of the total active C-17 fleet taken away from all other world mission requirements.

F.5 Troop Lift Capability

The C-17 has the capability to carry 102 troops (with no cargo or equipment), with centerline seats installed on the cargo floor and side-facing seats on each side of the cargo bay. With this, the C-17 will have to make 48 C-17 trips to carry the entire SBME force size of approximately 4,859 troops to the objective. Similarly, if Civil Reserve Air Fleet (CRAF) aircraft are used, at 300 troops per aircraft, it will take 17 CRAF to get them to the objective.

				VEHICLE CENTERLINES MORE THAN 8 INCHES FROM AIRCRAFT CENTERLINE (DOUBLE ROW)			VEHICLE CENTERLINE WITHIN 8" OF AIRCRAFT CENTERLINE (SINGLE ROW)	
					AXLE SPACING			±8" VEHICLE ℄ ACFT ℄
C-17 CARGO COMPARTMENTS	MAXIMUM ALLOWABLE WEIGHT IN COMPARTMENT (LB)	MAXIMUM ALLOWABLE PNEUMATIC TIRE INFLATABLE PRESSURE (PSI)	MAXIMUM ALLOWABLE WEIGHT PER LINEAR FOOT (LB)	SINGLE AXLES SIDE BY SIDE (LB)	BOGILS (TANDEM) SIDE BY SIDE (LB)	SINGLE AXLE BESIDE 4,500 LB. AXLE (LB)	SINGLE AXLE VEHICLE (WITHIN 8" OF CENTERLINE) (LB)	TRACKED VEHICLES (LB)
I	70,000	100	6,200	13,000	23,000 54" AXLE SPACING	22,000	27,000	UNDER 65,000
II	172,200	100	8,470	20,000	40,000 42" AXLE SPACING	27,000	36,000	OVER 65,000 (Veh. within 8" of centerline)
III	38,000	100	6,200	13,000	23,000 54" AXLE SPACING	22,000	27,000	UNDER 65,000
IV (RAMP)	40,000	100	6,200	13,000	23,000 54" AXLE SPACING	22,000	27,000	UNDER 65,000

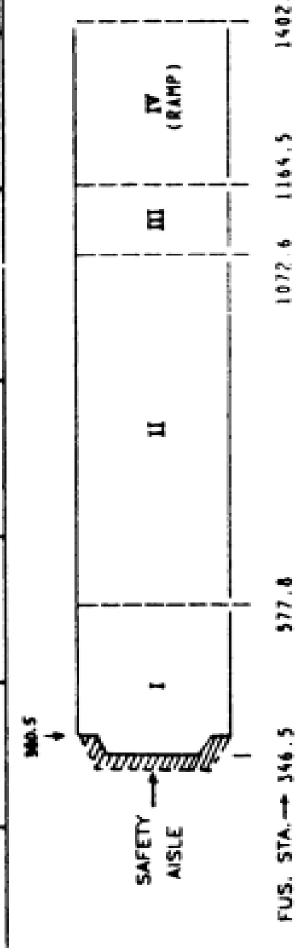


Figure F-4: C-17 Rolling Stock Load Limitations.

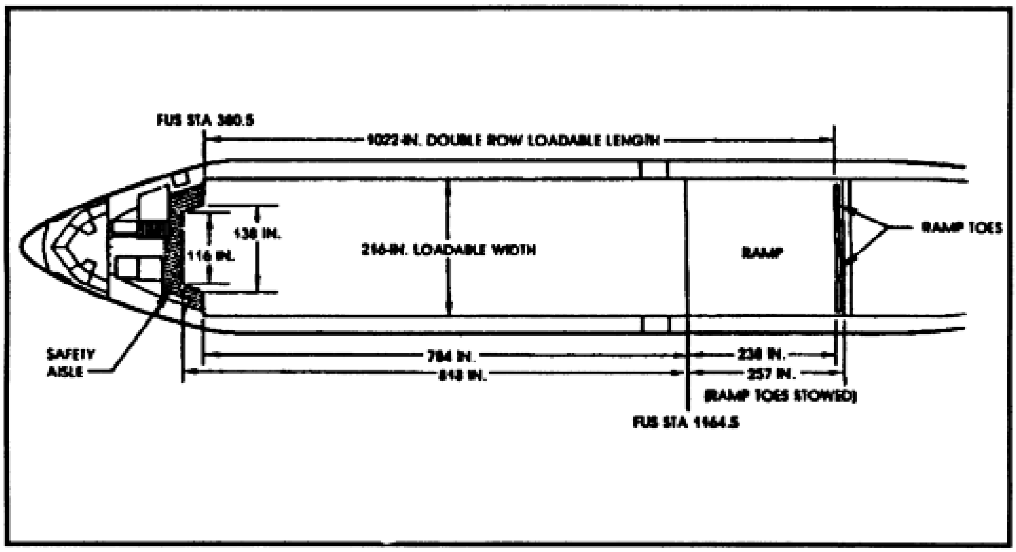


Figure F-5: C-17 Cargo Compartment Floor Dimensions.[452]

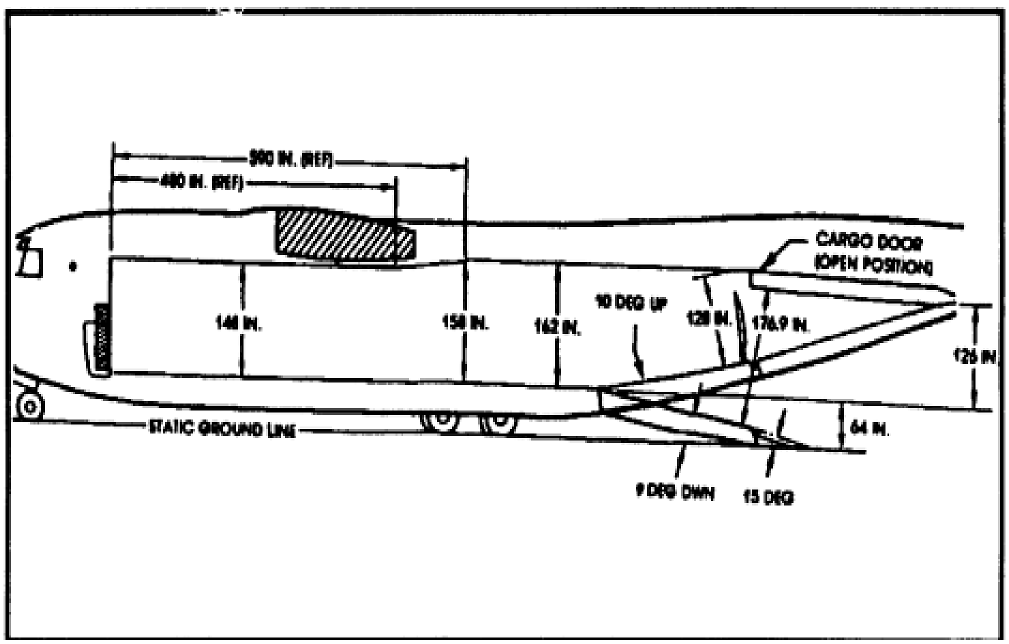


Figure F-6: C-17 Cargo Compartment Height Dimensions.[453]

[452] U.S. Army Air Mobility Command, C-17 Cargo Compartment Floor Dimensions, Figure 2-40, in <u>Chapter 2, Air Mobility Command Aircraft</u>, p. 44; available from World Wide Web @ http://www.globalsecurity.org/miitrsy/library/policy/army/fm/55-9/ch2.htm.
[453] Ibid., p 43.

USABLE CARGO AREA		RAMP LIMITATIONS
Length - 1,022 inches	Pallet:	Height - 96 inches
Width - 216 inches		Weight - 10,355 pounds[1]
Height - 142 inches[2]	Vehicle:	Height - 122 inches
Height - 156 inches[3]		Weight - 27,000 pounds per axle

[1]Not to exceed a combined total ramp weight of 40,000 pounds.
[2]Fuselage stations 381 to 971.
[3]Fuselage stations 971 to 1164.

NOTE: Exceptions may include items configured according to TB 55-46-1 or loaded according to the aircraft loading manual.

Figure F-7: C-17 Cargo Area Dimensions.[454]

[454] Ibid.

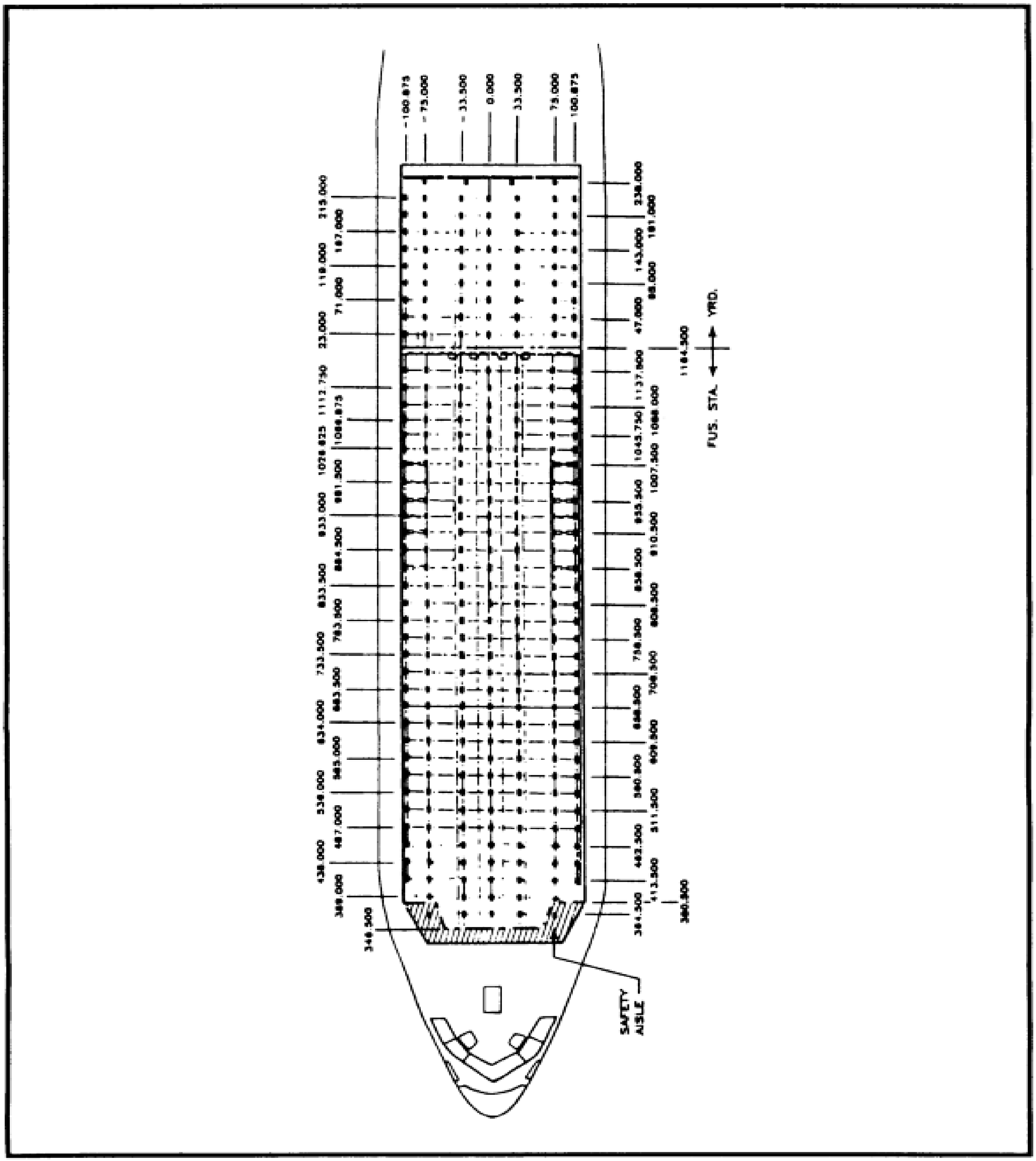


Figure F-8: C-17 Cargo Bay Schematic.[455]

455 Ibid., p. 44.

Appendix G: Glossary

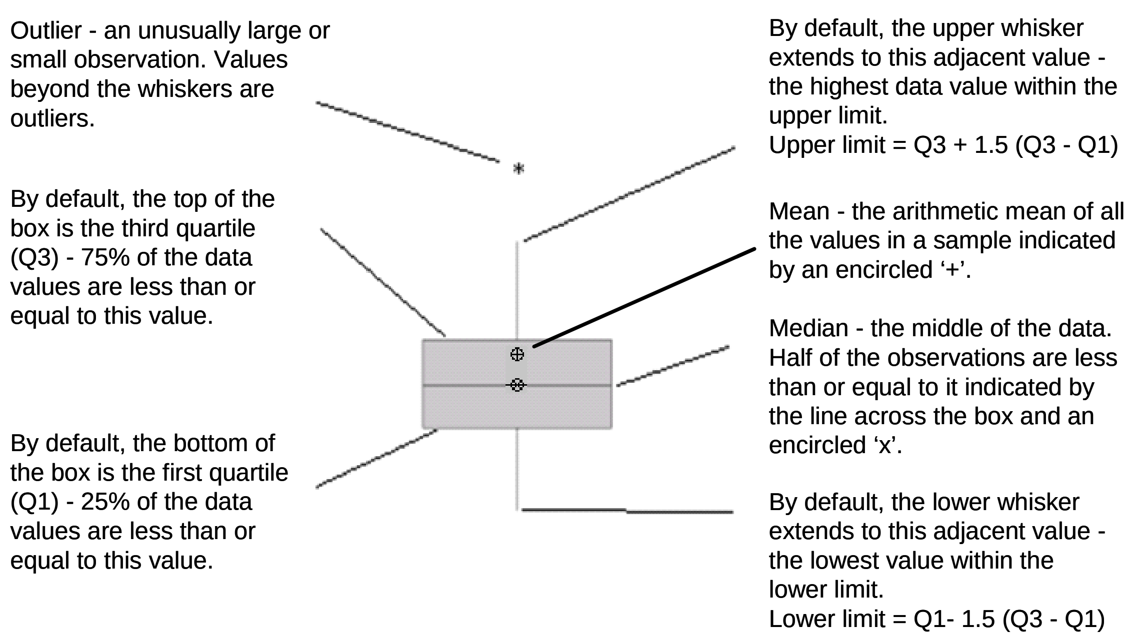
Acquisition Costs: The cost equal to the sum of the development cost for prime mission equipment and support items; the procurement cost for prime mission equipment, support items and initial spares; and the system specific facilities cost. (DAU Glossary of Defense Acquisition Acronyms and Terms)

Architecture: The structure of components, their relationships, and the principles and guidelines governing their design and evolution over time. (DoD Integrated Architecture Panel)

Average Procurement Unit Cost (APUC): APUC is calculated by dividing total procurement cost by the number of articles to be procured. Total procurement cost includes flyaway (which includes the recurring and nonrecurring costs associated with production of the item such as hardware/software, Systems Engineering (SE), engineering changes and warranties) plus the costs of procuring Technical Data (TD), training, support equipment and initial spares. (DAU Glossary of Defense Acquisition Acronyms and Terms)

Base Year (BY): A reference period which determines a fixed price level for comparison in economic escalation calculations and cost estimates. The price level index for BY is 1.000. (DAU Glossary of Defense Acquisition Acronyms and Terms)

Box Plot Symbology:



<u>Center of Gravity</u>: That source of massed strength—physical or moral, or a source of leverage—whose degradation, dislocation, neutralization, or destruction would have the most decisive impact on the enemy's or one's own ability to accomplish a given military objective.[456]

<u>Combat power</u>: The total means of destructive and/or disruptive force which a military unit/formation can apply against the opponent at a given time. (JP 1-02, North Atlantic Treaty Organization)

<u>Combined force</u>: A force composed of military elements of nations that have formed a temporary alliance for some specific purpose.[457] (JP 1-02)

<u>Combined operations</u>: An operation conducted by forces of two or more allied nations acting together for the accomplishment of a single mission.[458] (JP 1-02)

<u>Combined</u>: Between two or more forces or agencies of two or more allies. When not all allies or services are involved, the participating nations and services shall be identified (e.g., Combined Navies).[459] See also **Joint**. (JP 1-02)

<u>Command and Control (C2)</u>: C2 is the information system that is established to facilitate the coordination of the operations performed by Connectors, Inventory and Storage, and Transfers.

<u>Connector</u>: Any vehicle/platform/or combination of them that can: translate (move) itself; navigate; transport more people, materiel, and/or capability than it needs to translate and navigate; transfer the excess materiel to a needing platform or objective.

<u>Cost Analysis Requirement Description (CARD)</u>: A description of the salient features of the acquisition program and of the system itself. It is the common description of the technical and programmatic features of the program that is used by the teams preparing the Program Office (PO), Component Cost Analysis (CCA) and independent Life Cycle Cost Estimates (LCCE). (DAU Glossary of Defense Acquisition Acronyms and Terms)

<u>Critical Vulnerabilities</u>: Weakness, and sometimes strengths, that are open to the enemy's attack or can be exploited by the enemy.[460]

<u>Expedition</u>: A military operation conducted by an armed force to accomplish a specific objective in a foreign country.[461] (DoD)

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[456] Vego, Milan N., "Operational Warfare," (Newport: Naval War College Press, 2000) p. 634.
[457] National Defense University, Joint Forces Staff College, *The Joint Staff Officers Guide.* (Norfolk: 2000), p. G-24.
[458] Ibid., p. G-25.
[459] Ibid., p. G-25.
[460] Vego, p. 636.
[461] Defense Technical Information Center, *Expedition*. <http://www.dtic.mil/doctrine/jel/doddict/data/e/01953.html> (15 July 2004).

Expeditionary force: An armed force organized to accomplish a specific objective in a foreign country.[462] (DoD)

Inventory and Storage: Inventory and Storage consists of strike-up/strike-down, which includes storerooms, inventory management systems and all equipment and space necessary to manage, store, repackage and move cargo. Additionally, for the purpose of this study, Inventory and Storage will include assembly, assembly spaces, equipment storage spaces, ground vehicle and aircraft maintenance spaces, hangar spaces, medical facilities and all other spaces and services required for a brigade-sized force distributed between the squadron ships.

Joint force: A general term applied to a force composed of significant elements, assigned or attached, of two or more Military Departments, operating under a single joint force commander.[463] (JP 1-02)

Joint: Connotes activities, operations, organizations, etc., in which elements of two or more Military Departments participate.[464] (JP 1-02)

LAPES: An aerial delivery method of up to 38,000 lbs of cargo is pulled from the aircraft by large cargo parachutes while the aircraft is 5 to 10 ft above the ground. The load then slides to a stop within a very short distance.

Life Cycle Cost (LCC): The total cost to the government of acquisition and ownership of that system over its useful life. It includes the cost of development, acquisition, operations, and support (to include manpower), and where applicable, disposal. For defense systems, LCC is also called Total Ownership Cost (TOC). (DAU Glossary of Defense Acquisition Acronyms and Terms)

Logistics: The science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, those aspects of military operations that deal with: 1. design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of materiel; 2. movement, evacuation, and hospitalization of personnel; 3. acquisition or construction, maintenance, operation, and disposition of facilities; 4. acquisition or furnishing of services. (Defense Technical Information Center, "logistics," DOD Dictionary of Military Terms)

Needline: A requirement that is the logical expression of the need to transfer information among nodes. (DODAF Volume I)

Node: A representation of an element of architecture that produces, consumes, or processes data. (DODAF Volume I)

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[462] Defense Technical Information Center, *Expeditionary Force*.
< http://www.dtic.mil/doctrine/jel/doddict/data/e/01954.html> (15 July 2004).
[463] *The Joint Staff Officers Guide*, p. G-43.
[464] Ibid., p. G-42.

Non-Recurring Costs: Those costs that are not repetitive, even though the total expenditure may be cumulative over a relatively short period of time. Non-recurring costs typically involve developing or establishing a capacity to operate. (DAU Glossary of Defense Acquisition Acronyms and Terms)

Operational Node: A node that performs a role or mission. (DODAF Volume I)

Oversized: Does not fit in a standard container.

Procurement Costs: The cost equal to the sum of the procurement cost for prime mission equipment, the procurement cost for support items, and the procurement cost for initial spares. (DAU Glossary of Defense Acquisition Acronyms and Terms)

Recurring Costs: Those costs that are repetitive and occur when a company produces similar goods or services on a continuing basis. (DAU Glossary of Defense Acquisition Acronyms and Terms)

Sea Base: A maritime vessel or group of maritime vessels with sufficient Command and Control (C2) and logistical systems available to support Joint Expeditionary Operations (JEO).

Seabasing: A national capability; is the overarching transformational operating concept for projecting and sustaining naval power and joint forces, which assures joint access by leveraging the operational maneuver of sovereign, distributed, and networked forces operating globally from the sea. (Naval Warfare Development Command, "Sea Basing SharePoint Site)

Selective Acquisition Report (SAR): Standard, comprehensive, summary status report of Major Defense Acquisition Program (MDAP) (Acquisition Category (ACAT)I) required for periodic submission to Congress. It includes key cost, schedule and technical information. (DAU Glossary of Defense Acquisition Acronyms and Terms)

Supply class: The grouping of supplies by type into ten categories to facilitate supply management and planning.[465]

Examples:

I. Subsistence items (Meals, Ready-to-Eat, T-rations, and fresh fruits and vegetables) and gratuitous-issue health and comfort items.
II. Clothing, individual equipment, tentage, organizational tool sets and kits, hand tools, maps, and administrative and housekeeping supplies and equipment.
III. Petroleum fuels, lubricants, hydraulic and insulating oils, preservatives, liquids and gases, bulk chemical products, coolants, deicer and antifreeze

[465] Ibid., pp.G-22 - G-23.

compounds, components and additives of petroleum and chemical products, and coal.

IV. Construction materials including installed equipment, and all fortification and obstacle materials.

V. Ammunition of all types including chemical, bombs, explosives, mines, fuzes, detonators, pyrotechnics, missiles, rockets, propellants, and other associated items.

VI. Personal demand items such as health and hygiene products, writing material, snack food, beverages, cigarettes, batteries and cameras (nonmilitary items).

VII. Major end items such as launchers, tanks, mobile machine shops and vehicles.

VIII. Medical material, including repair parts peculiar to medical equipment and management of blood.

IX. Repair parts and components, to include kits, assemblies, and subassemblies (repairable or nonrepairable), that are required for maintenance support of all equipment.

X. Material required to support nonmilitary programs such as agricultural and economic development projects (not included in classes I through IX). MISC. Water, captured enemy material, salvage material.

Sustainment: The provision of personnel, logistic, and other support required to maintain and prolong operations or combat until successful accomplishment or revision of the mission or of the national objective.[466] (JP 1-02)

Synchronization: Process of arranging or initiating actions aimed at generating maximum relative (combat or non-combat) power at a decisive place and time; sound synchronization must ensure that all elements of one's force, collectively, generate synergistic effects that exceed the sum of their individual effects; depending on the purpose, tactical, operational and strategic synchronization is differentiated.[467]

Systems Node: A node with the identification and allocation of resources (e.g., platforms, units, facilities and locations) required to implement specific roles and missions. (DODAF Volume I)

Total Ownership Cost (TOC): A concept designed to determine the true cost of design, development, ownership and support of DoD weapons systems. At the DoD level, TOC is comprised of the costs to research, develop, acquire, own, operate, and dispose of defense systems, other equipment, and real property; the cost to recruit, retain, separate, and otherwise support military and civilian personnel; and all other costs of the business operations of the DoD. At the individual program level, TOC is synonymous with the Life Cycle Cost (LCC) of the system. (DAU Glossary of Defense Acquisition Acronyms and Terms)

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[466] Ibid., p. G-76.

[467] Vego, p. 648.

Transfer: A process and/or mechanism that moves personnel and materiel between connectors and/or between a connector and an objective. The transfer mechanism is composed of all components required to enable the transfer mechanism to operate. This may include components that are either temporarily transported on or a permanent fixture of a Connector.

Vectored Thrust: Directional thrust from swiveling propeller ducts, permitting an airship to take off with heavier than neutral buoyancy or land with lighter than neutral buoyancy.

Work Breakdown Structure (WBS): An organized method to break down a project into logical subdivisions or subprojects at lower and lower levels of details. It is very useful in organizing a project. (DAU Glossary of Defense Acquisition Acronyms and Terms)

Appendix H: Acronyms

2015 BLA	2015 Baseline Architecture
4^{th} ID	Fourth Infantry Division
A/C	Aircraft
AA1	2025 Alternative Architecture 1
AA2	2025 Alternative Architecture 2
AA3	2025 Alternative Architecture 3
AAA	Anti – Air Artillery
AAFARS	Advanced Aviation Forward Area Refueling System
AAV	Amphibious Assault Vehicles
ABV	Assault Breaching Vehicle
ACAT	Acquisition Category
ACCESS	Amphibious Combat Cargo Expeditionary Support Ship
ACD	Advanced Concept Demonstrations
ACE	Air Combat Element
ACE	Armored Combat Earthmover
ACQ	Acquisition
ACTD	Advanced Concept Technology Demonstrations
ADA	Air Defense Artillery
AE	Assault Echelon
AFIT	Air Force Institute of Technology
AFOE	Assault Follow-On Echelon
AFSB	Afloat Forward Staging base
AGAS	Affordable Guided Airdrop System
AIS	Automated Information System
AIT	Automatic Information Technology
ALG	Acquisition Logistics Guide
AMB	Ambulance
AMC	Air Mobility Command
AMSU	Aeronautical Material Screening Unit
ANOVA	Analysis of Variance
ANSI	American National Standards Institute
AO	Area of Operations
AoA	Analysis of Alternatives
AOR	Area of Responsibility
APOD	Air Port of Debarkation
APUC	Average Procurement Unit Cost
ARG	Amphibious Readiness Group
ARV-A (L)	Armed Robotic Vehicle-Assault (Light)
ARV-A	Armed Robotic Vehicle-Assault
ARV-RSTA	ARV-Reconnaissance, Surveillance and Target Acquisition
ASCM	Anti-Ship Cruise Missile
ASEAN	Association of Southeast Asian Nations

ASN(RD&A)	Assistant Secretary of the Navy for Research, Development and Acquisition)
ATG	Advanced Technologies Group
ATGM	Anti-Tank Guided Munitions
ATT	Advanced Theater Transport
AV	All-Views
AVLB	Armored Vehicle Launched Bridge
AVN	Aviation
bbls	Barrels
BCT	Brigade Combat Team
BIC	Brigade Intelligence and Communication
BLA	Baseline Architecture
BLT	Battalion Landing Team
BY	Base Year
C2	Command and Control
C2V	Command and Control Vehicle
CA	Combined Arms
CARD	Cost Analysis Requirements Description
CAS	Close Air Support
CCA	Component Cost Analysis
C-DAY	Operation Commencement Day
CE	Combat Element
CER	Cost Estimating Relationships
CES	Commander's Estimate of the Situation
CF	Complexity Factors
CFLCC	Combined Forces Land Component Command
CIA	Central Intelligence Agency
CIC	Command Integration Cell
CJCS	Chairman of the Joint Chiefs of Staff
CJCSM	Chairman of the Joint Chiefs of Staff Manual
CJTF	Combined Joint Task Force
CL	Class
CLF	Combat Logistics Force
CLP	Common Logistics Picture
CMS	Controlled Material Security
CNA	Center for Naval Analysis
CNO	Chief of Naval Operations
CO	Commanding Officer
COA	Courses of Action
COG	Center of Gravity
COI	Critical Operational Issue
COMCDR	Commander of a Combatant Command
CONOPS	Concept of Operations
CONUS	Continental United States
COP	Common Operational Picture

CRAF	Civil Reserve Air Fleet
CSB	Commander, Sea Base
CSBME	Commander, Sea Base Maneuver Element
CSG	Carrier Strike Group
CSSE	Combat Service Support Element
CTF CDR	Combined Task Force Commander
CTF	Combined Task Force
CV	Carrier
DART	Defense Adaptive Red Team
DAU	Defense Acquisition University
DLA	Defense Logistics Agency
DoD	Department of Defense
DODAF	Department of Defense Architecture Framework
DOS	Days of Supply
DOTMLPF	Doctrine, Organization, Training, Material, Leadership and education, Personnel, and Facilities
DPICM	Dual-Purpose Improved Conventional Munition
DR	Data Requirement
E.U.	European Union
EFSS	Expeditionary Fire Support System
EFV	Expeditionary Fighting Vehicle
EOD	Explosive Ordnance Disposal
EOQ	Economic Order Quantity
EPC	Electronic Product CodeTM
ESG	Expeditionary Strike Group
ESS	Expeditionary Strike Ship
EUCOM	European Command
EXFOR	Expeditionary Forces
EXPWARTRAGRUPAC	Expeditionary Warfare Training Group, Pacific
EXWAR	Expeditionary Warfare
FAA	Functional Area Analysis
FARP	Forward Advanced Refueling Base
FAS	Federation of American Scientists
FBE	Forward Base Echelon
FCF	Functional Check Flight
FCS	Future Combat System
FIE	Fly-In Echelon
FLS	Forward Logistics Site
FNA	Functional Needs Analysis
FRMV	Future Recovery Maintenance Vehicle
FSA	Functional Solution Analysis
FSB	Forward Support Battalion
FTR	V-44 Future Transport Rotorcraft
FY	Fiscal Year
GCCS-J	Global Command & Control System-Joint

GCE	Ground Combat Element
GFE	Government-Furnished Equipment
GIG	Global Information Grid
GSTAMIDS	Ground Standoff Minefield Detection System
GWOT	Global War on Terrorism
Helo	Helicopter
HEMMT	Heavy Expanded Mobility Tactical Truck
HEMMT-LHS	HEMMT-Load Handling System
HHC	Headquarters and Headquarters Company
HIMARS	High Mobility Artillery Rocket System
HLCAC	Heavy Landing Craft, Air Cushion
HMH	Marine Heavy Helicopter Squadron
HMLA	Marine Light Attack Squadron
HMM	Marine Medium Helicopter Squadron
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HQMC	Headquarters U. S. Marine Corps
HSAC	High Speed Assault Connector
HSV	High Speed Vessel
HTARS	HEMMT Tanker Aviation Refueling System
HULA	Hybrid Ultra Large Aircraft
I&S	Inventory and Storage
ICV	Infantry Carrier Vehicle
ID	Infantry Division
IED	Improvised Explosive Device
IEEE	Institute of Electrical and Electronics Engineers
I-Level	Intermediate Level
ILP	Integrated Landing Platform
IM	Intermediate Maintenance
IMA	Intermediate Maintenance Activity
IMS	Inventory Management System
INCOSE	International Council on Systems Engineering
IPT	Integrated Product Team
ISO	International Standards Organization
ISR	Intelligence Surveillance & Reconnaissance
ITV	Internally Transportable Vehicle
JAOC	Joint Air Operations Center
JCATS	Joint Conflict and Tactical Simulation
JCIDS	Joint Capabilities Integration and Development System
JEB	Joint Expeditionary Brigade
JEF	Joint Expeditionary Force
JELo	Joint Expeditionary Logistics
JEO	Joint Expeditionary Operations
JFEO	Joint Forcible Entry Operations
JFLCC	Joint Force Land Component Commander
JFMCC	Joint Forces Maritime Component Commander

JLOTS	Joint Logistics Over The Shore
JMIC	Joint Inter-Modal Container
JOA	Joint Operations Area
JOC	Joint Operational Concepts
JOPES	Joint Operation Planning and Executing System
JP	Jet Propellants
JP	Joint Publication
JSF	Joint Strike Fighter
JTAV	Joint Total Asset Visibility
JTF	Joint Task Force
JTFC	Joint Task Force Commander
JTFEX	Joint Task Force Exercise
kts	Knots
L/C	Launcher/Control
LAAD	Low Altitude Air Defense
LAPES	Low Altitude Parachute Extraction System
LAV	Light Armored Vehicle
lbs	Pounds
LCAC	Landing Craft, Air Cushion
LCC	Amphibious Command Ship
LCC	Life Cycle Cost
LCCE	Life Cycle Cost Estimation
LCCE	Life Cycle Cost Estimation
LCU	Landing Craft Utility
LCU(R)	Landing Craft Utility, Replacement
LFORM	Landing Force Operational Readiness Material
L-HOUR	Operation Launch Time
LHS	Load Handling System
LID	Light Infantry Divisions
LMSR	Large, Medium Speed, Roll-On/Roll-Off Ship
LOC	Lines of Communitcation
LRIP	Low Rate Initial Production
LVS	Logistics Vehicle System
M	Materiel
M9 ACE	M9 Armored Combat Earthmover
MACG	Marine Air Control Group
MAGTF	Marine Air Ground Task Force
MAX	Maximum
MCCDC	Marine Corps Combat Development Command
MCM	Mine Counter Measure
MCO	Major Combat Operation
MCS	Mounted Combat System
MDA	Milestone Decision Authority
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program

MEB	Marine Expeditionary Brigade
MEDEVAC	Medical Evacuation
MET	Meteorological
MEU	Marine Expeditionary Unit
MHE	Materiel Handling Equipment
MILCON	Military Construction
MILPERS	Military Personnel
MISC	Miscellaneous
MIW	Mine Interdiction Warfare
MLOG	Mean Logistics Delay
MLRS	Multiple Launch Rocket System
MODLOC	Modified Location
MOE	Measure of Effectiveness
MOP	Measure of Performance
MORSS	Military Operations Research Society Symposium
MPF	Maritime Prepositioning Force
MPF(F)	Maritime Preposition Force (Future)
MPG	Maritime Prepositioning Group
M-POOL	Materiel Pool
MPS	Maritime Prepositioning Squadron
MRE	Meal, Ready to Eat
MSC	Military Sealift Command
MSSG	MEU Service Support Element
MT	Metric Ton
MTBF	Mean Time Between Failure
Mtd	Mounted
MTTR	Mean Time to Repair
MTVR	Medium Tactical Vehicle Replacement
MULE	Multi-function Utility/Logistics and Equipment
MV-E	Medical Vehicle-Evacuation
MV-T	Medical Vehicle-Treatment
MWSG	Marine Wing Support Group
n.d.	No date
N/A	Not Applicable
NAMP	Naval Aviation Maintenance Program
NATO	North Atlantic Treaty Organization
NATOPS	Naval Air Training and Operating Procedures Standardization
NAVAIR	Naval Air Warfare Center
NAVSEA	Naval Sea Systems Command
NAVSTORS	Navy Storage and Retrieval System
NCAD	Naval Cost Analysis Division
NDI	Non-Destructive Inspection
NDIA	National Defense Industrial Association
NETOPS	Network Operations
NLOS	Non-Line of Sight

NLOS-LS	Non-Line of Sight -Launch System
NM	Nautical Mile
NORM	Normal
NORMDIST	Microsoft's Excel Function: Normal Distribution
NPS	Naval Postgraduate School
NRAC	Naval Research Advisory Committee
NSDA	Non Self-Deploying Aircraft
NSE	Naval Support Element
NSWC	Naval Surface Warfare Center
NSWCCD	Naval Surface Warfare Center, Carderock Division
O & O	Operational and Organizational
O to D	Organizational to Depot Level
O&M	Operation and Maintenance
O&S	Operating and Support
OBJ	Objective
OBS	Operation Burmese Sanctuary
OH	On Hand
O-Level	Organizational Level
OMFTS	Operational Maneuver from the Sea
OOB	Order of Battle
OP	Operational level of war
OPLAN	Operational Plan
OPNAV N7	Deputy Chief of Naval Operations for Warfare Requirements and Programs
OPNAVINST	Operational Naval Instruction
OPSCON	Operating Concept
OPT	Operation Piranha Treasure
ORD	Operational Requirements Document
OV	Operational View
PACOM	Commander, U.S. Pacific Command
PACSAT	Partial Air Cushion Support Catamaran
PEO	Program Executive Office
PHST	Packaging, Handling, Storage and Transportation
Pk	Probability of Kill
PLA	Peoples Liberation Army
PLAN	Peoples Liberation Army Navy
PLS	Palletized Loading System
PME	Prime Mission Equipment
PMP	Project Management Plan
PO	Program Office
POD	Period of Darkness
POL	Petroleum, Oil and Lubricants
PR	Program of Record
PRC	Peoples Republic of China
P_S	Probability of Survival

PTM	Personnel Transport Module
Q1	First Quartile
Q3	Third Quartile
QA	Quality Assurance
QTY	Quantity
R&D	Research and Development
R&SV	Reconnaissance and Surveillance Vehicle
R/W	Rotary-wing
R1	Sea Base-to-shore range
R2	Shore-to-objective range
RDT&E	Research, Development, Testing, and Evaluation
RFID	Radio Frequency Identification
RFP	Request for Proposals
RO/RO	Roll-on/Roll-off
RON	Remain Over Night
RSLS	Rapid Strategic Lift Ship
SAM	Surface – Air Missile
SAR	Selected Acquisition Report
SB	Sea base
SBME	Sea Base Maneuver Element
SBSE	Sea Base Support Element
SE	Support Equipment
SE	Systems Engineering
SEA	Systems Engineering and Analysis
SEA-4	Systems Engineering and Analysis Cohort Four
SEA-5	Systems Engineering and Analysis Cohort Five
SEA-6	Systems Engineering and Analysis Cohort Six
SEABASE-6	Systems Engineering Analysis Baseline Architecture System Evaluator Six
SEAD	Suppression of Enemy Air Defenses
SECDEF	Secretary of Defense
SEI-3	Systems Engineering and Integration Cohort Three
SLEP	Service Life Extension Program
Sm	Small
SOA	Speed of Advance
SOAE	Sustained Operations Ashore Echelon
SOC	Special Operations Command
SOF	Special Operations Force
SPT	Support
Sq ft	Square feet
SS	Sea State
SSF	South Sea Fleet
SSM	Surface – Surface Missile
ST	Strategic level of war
STOM	Ship to Objective Maneuver

STOVL	Short Takeoff/Vertical Landing
STREAM	Standard Tensioned Replenishment Along-Side Method
SV	Systems View
SV04	Sea Viking 2004
T/R	Tilt-rotor
TA	Tactical level of war
T-AOE	Fast Combat Support Ship
T-AOE(X)	Fast Combat Support Ship Future
TBF	Time Between Failure
TBMD	Theater Ballistic Missile Defense
T_{CONUS_FLS}	Time (in hrs) from CONUS to FLS
T_{CRIT}	Time (in hrs) critical
TD	Technical Data
T_{DEPLOY}	Time (in hrs) for MPF(F) to deploy
TEU	Twenty Foot Equivalent Unit (20-ft container)
T_{GIVEN}	Time (in hrs) given
THAAD	Theater High-Altitude Area Defense
T_{LOAD}	Time (in hrs) to load
TOA	Total Obligation Authority
TOC	Total Ownership Cost
TOR	Connector
TRAC	TRADOC Analysis Center
TRADOC	Training and Doctrine Command
Trlr	Trailer
TSSE	Total Ships Systems Engineering
T_{STORE}	Time (in hrs) to store
TSV	Theater Support Vessel
TTR	Time To Repair
T_{UNLOAD}	Time (in hrs) to unload
T_{UW}	Time (in hrs) underway
TV	Technical Standards View
TWMP	Track Width Mine Plow
T_{XIT}	Time (in hrs) to conduct transit
U.N.	United Nations
U.S.	United States
UA	Unit of Action
UAV	Unmanned Aerial Vehicle
UE	Units of Employment
UGV	Unmanned Ground Vehicle
UID	Unique Identification
UJTL	Universal Joint Task List
UNREP	Underway Replenishments
US	United States
USA	United States Army
USAF	United States Air Force

USMC	United States Marine Corps
USN	United States Navy
USSOCOM	United States Special Operations Command
USTRANSCOM	United States Transportation Command
UV	Unmanned Vehicle
VAMOSC	Visibility and Management of Operating and Support Costs
Veh	Vehicle
VERTREP	Vertical Replenishment
VMA	Marine Attack Squadron
VMGR	Marine Aerial Re-fueling/Transport Squadron
VSTOL	Vertical/Short Takeoff and Landing
VTOL	Vertical Takeoff and Landing
VTUAV	Vertical Take-off Unmanned Aerial Vehicle
WBS	Work Breakdown Structure
WTO	World Trade Organization
XFER	Transfer system

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